CHARLES FONDACARO
67-119A

6000 AND 6001 SERIES DIGITAL VOLTMETERS MODELS 26.257 & 26.203

Publ. No. D800 5003 01)

EAI

ELECTRONIC ASSOCIATES INC. ■ LONG BRANCH, NEW JERSEY

EAI

ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

6000 AND 6001 SERIES DIGITAL VOLTMETERS MODELS 26.257 & 26.203

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PAGE	ITEM / PARA	REVISION
5		Change the full scale step Input Response table as follows: Response time of the 10V range changes from 40 to 50 milliseconds. Response time of the 100V range changes from 50 to 25 milliseconds. Response time of the 1000V range changes from 40 to 50 milliseconds.
5		Change the second sentence of the single asterisk note as follows: ... on the 10 volt range does not exceed 0.02 ...
11		Change Table 5 as follows: Delete the asterisk from the electrical characteristics portion of the last entry.
17	2g	Change first sentence as follows: Set the dc source for a positive output of less than 1 volt.
18	3b	Change sentence as follows: ... an overload of $\geq$120 volts applied ...
18	3c	Change sentence as follows: ... a voltage $\geq$120 volts may ...
19	3e	Change sentence as follows: ... time a voltage $\geq$120 volts is applied to the 10 volt range.
45		Change the fifth line of the second paragraph as follows: ... the programmer for the duration of the range change ...
45		Change the sixth line of the second paragraph as follows: ... indicating to the operator that a range change is in effect ...
58	4(2)	Change the second sentence as follows: The readout should be between +9.998 and +10.002 ...

DATE 2/15/65

MANUAL TITLE 6000 and 6001 SERIES DIGITAL VOLTMETERS
MODELS 26.257 and 26.203

REVISION NOTICE NO. 65-5
SH. 1 OF 2 SH.

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MANUAL REVISION NOTICE*

ELECTRONIC ASSOCIATES INC.
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PAGE	ITEM / PARA	REVISION
64		Change Table as follows:

Apply Input for DVM Readout of	Decrease Input for Readout of	Decrease Input for Readout of
-80.01V	-80.00V	-79.99V
-40.01V	-40.00V	-39.99V
-20.01V	-20.00V	-19.99V
-10.01V	-10.00V	-09.99V
-08.01V	-08.00V	-07.99V
-04.01V	-04.00V	-03.99V

64

Change the first sentence of the first paragraph as follows:
... (for example if the DVM switches from -80.01 volts to -80.00 volts but jumps to -79.98 as the input is decreased thus skipping -79.99) ...

In later models of the 6000 and 6001 series Digital Voltmeters the 44.271 Programmer has been replaced by the 44.302 Programmer. For schematic information for the 44.271 Programmer see drawing D044 271 OS. See drawing D044 302 OS for schematic information on the 44.302 Programmer.

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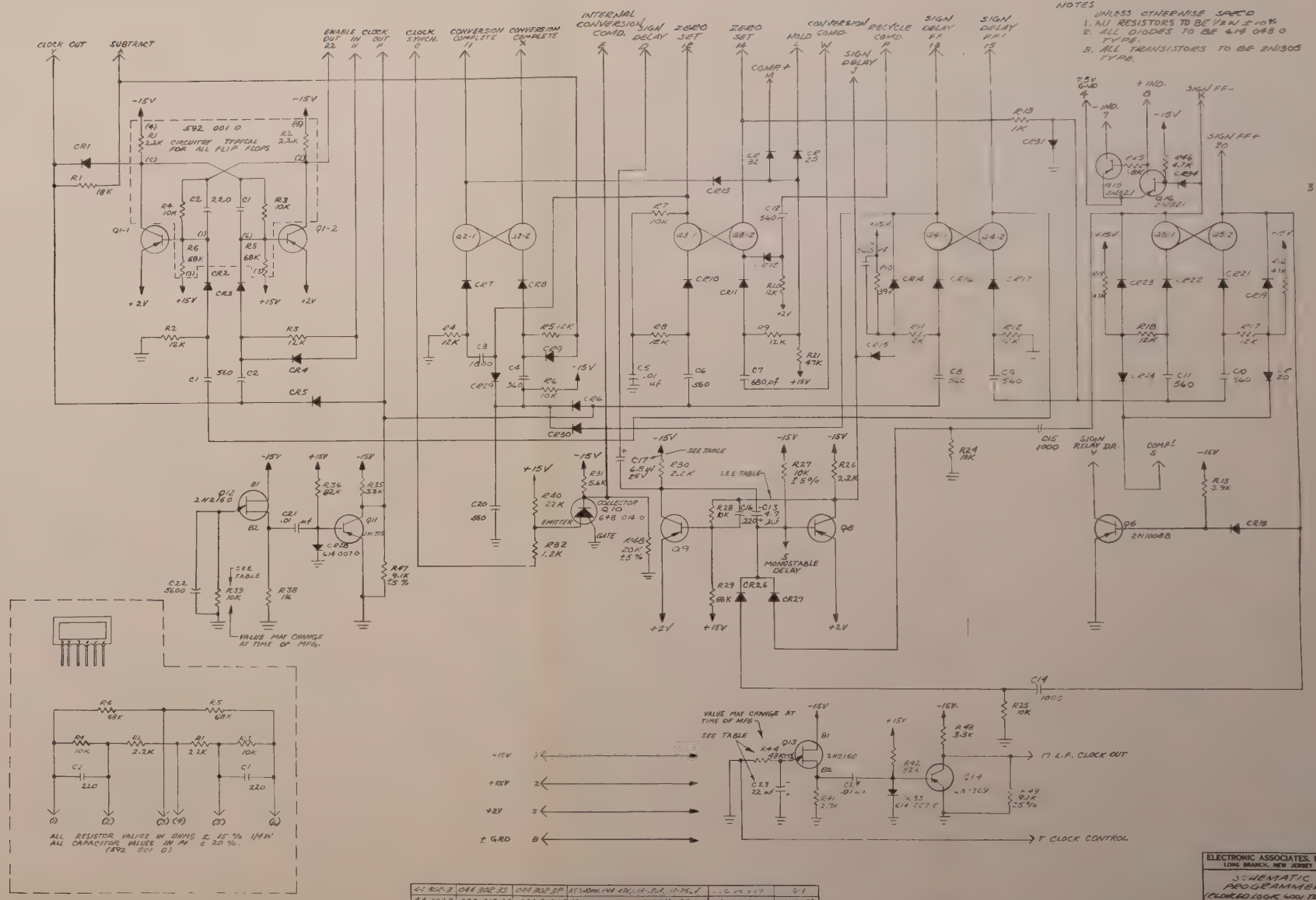

44 302-3	044 302 3S	044 302 3P	AS SHOWN (-44 -48, -54, -57, -71, -75)		273
44 302 2	044 302 2S	044 302 2P	AS SHOWN (-44, -48, -54, -57, -71, -75)	A026 254 JA	1EN7459
44.302 1	044 302 1S	044 302 1P	AS SHOWN (-44, -48, -54, -57, -71, -75) EXCEPT R38 = 200K ± 2% R39 = 5.11K ± 1%	A026 183 QP	1724
44.302	D044 302 0S	A044 302 0P	AS SHOWN VALUE OF R46 = 43K	A026 203 QP	1723
UNIT NUMBER	SCHEMATIC NUMBER	PARTS LIST & MAT'L ASSY	DESCRIPTION	PARTS LIST USED ON	PROJECT NO.

TABLE OF UNIT NUMBERS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN MF
RESISTANCE IS IN OHMS
TOLERANCE OF: .X = ± .03 .XX = ± .02
.XXX = ± .010 .XXX = ± .005 ∠ = ± 1°
* TOL. OF MATERIAL THICKNESS

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SCHEMATIC PROGRAMMER (CLOCKED LOGIC 400 TOWER)
SHT. NO.
SIZE
REV. NO.
PROJECT ENG. J.T.A.
D044 302 0S
SHEET 1 OF 1 SHEETS

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(a) 6001 Series (for Rack Mounting)

(b) 6000 Series (with Bench Cover)

Figure 1. 6000 and 6001 Series Digital Voltmeters

CHAPTER 1

GENERAL DESCRIPTION

1. INTRODUCTION

The 6000 and 6001 Series Digital Voltmeters (DVM), Models 26.257 and 26.203 respectively are designed and manufactured by EAI (Electronic Associates, Inc.). These instruments are capable of accurately and rapidly measuring dc voltages. They are entirely self contained, including all power supplies and an accurate, stable, reference voltage source. The 6001 DVM (Figure 1) features both automatic and manual range selection (with an automatic overload protection circuit when used in the manual range mode), and a 20% overrange capability. The 6000 DVM features manual range selection with a 20% overrange capability.

The voltage being measured is displayed on a five-digit luminous readout unit that indicates both magnitude and polarity of this voltage. The front-panel-mounted readout indicators consist of a high-brilliance optical system which permits wide angle viewing even under adverse ambient light conditions.

The DVM's present a high input impedance to the input source (10 megohms minimum); the input impedance is not dependent on a *null* condition of the DVM. This feature eliminates variable loading of the input source during the DVM sampling cycle. Each instrument is capable of accurately measuring voltages from 0 to 1000 volts in four ranges (plus the 20% overrange on each range): 0 to 1 volt, 0 to 10 volts, 0 to 100 volts, and 0 to 1000 volts.

The DVM's function as analog-to-digital converters using a programmed-comparison type circuit in which the current produced by the unknown is compared with an internally generated known binary-coded decimal (BCD) current. When the BCD current equals the unknown current the resultant BCD output of the converter is decoded to the common decimal form and displayed on the visual readout. The sampling rate is fixed at one millisecond (without polarity or range change); however, the sampling-cycle frequency is dependent on one of the four trigger sources.

Both the decimal and the BCD voltage equivalents (plus the polarity) are brought out to a rear mounted connector. The DVM's may therefore be used for such functions as controlling a printer, a tape or card punch, or for driving a remote readout display module.

2. PHYSICAL DESCRIPTION

These instruments are designed for either bench use or for rack mounting. All component parts of the DVM's are contained in a 19 inch U-type chassis which is compatible with the standard 19 inch RETMA or the EAI single bay rack requirements. The overall dimensions and weight of the 6000 and 6001 DVM's are given in Table 1.

Table 1. DVM Physical Data

Description	Dimensions
Height - Front Panel (W/O Case)	5-1/4 Inches
Height (With Case)	6-1/4 Inches
Width (RETMA Panel)	19 Inches
Width (With Case)	19-1/2 Inches
Depth - Edge of Front Panel to Rear of Fan	16 Inches
Depth (With Case)	17-1/4 Inches
Weight (W/O Case)	28 Pounds
Weight (With Case)	43 Pounds
Mounting Screw Size (RETMA Rack) 4 Each	10-32
Mounting Screw Size (EAI Rack) 4 Each	1/4-20

Table 2 lists the external connectors of the DVM giving the EAI part number of the connector and also the EAI part number of the mating connector. (See Figure 2.)

Table 2. DVM Connectors and Mating Plugs

Connector Designation	Description	EAI Part Number	EAI Part Number of Mating Connector
P1 and P4	78 Pin Connectors	EAI 542 123 0	EAI 542 122 0
P2	25 Pin Test Connector	EAI 542 099 0	EAI 542 098 0
J1 and J2	Input Connectors	EAI 542 1159 0	EAI 542 1160 0*

Most of the DVM components (with the exception of the power supplies and certain networks) are mounted on removable plug-in assemblies. Table 3 lists the various assemblies and gives the chassis-mounted connector designation. The location of each item is shown in Figure 2.

**A 542 1160 0 connector complete with 6 feet of input cable is supplied with each DVM.*

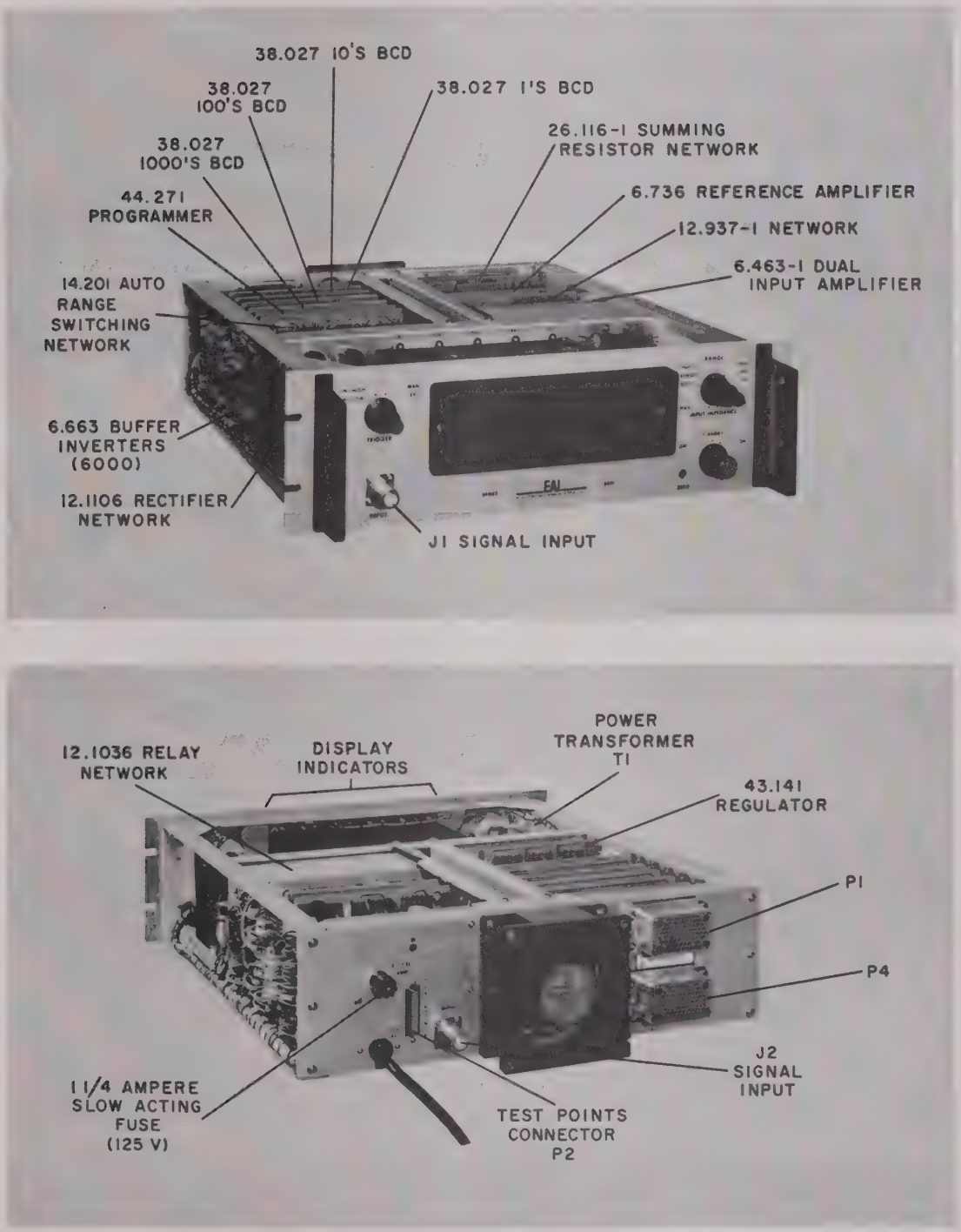


Figure 2. DVM Component Location, Front and Rear Views

Table 3. Plug-In Printed Circuit Cards and Components

Component	Model Number	Quantity	Connector Designation
Dual DC Amplifier	6.463-1	1 Each	AR2
Reference Amplifier	6.736	1 Each	AR1
Network Card	12.937-1	1 Each	NW3
Relay Network	12.1036	1 Each	NW5
Auto Range Switch Circuit (6001 Series Only)	14.201-1	1 Each	A6
Summing Resistor Network	26.116-1	1 Each	NW2
Comparator and Diode Gate	26.242	1 Each	A8
BCD-Decoding Matrix/Counter	38.027	3 Each	A1, A2, A3
BCD-Decimal Decoding Matrix/Counter	38.027-1	1 Each	A4
Power Supply Regulator	43.141	1 Each	VR1
Programmer	44.271	1 Each	A5

In addition to the plug-in cards other components, in the form of network assemblies, are mounted on the DVM chassis. These units can be removed, however, removal usually involves un-soldering connections, etc. Location of these components is shown in Figure 2.

Table 4. Additional DVM Components

Component	Designation	Quantity
Rectifier Network 12.1106	NW4	1 Each
Transformer	T1	1 Each
Digital Display Indicators	DS1-DS4	4 Each
Digital Display Indicators	DS5	1 Each
Buffer Inverter 6.663 (6000 Only)	NW6	1 Each
Reed Relay K1	AK1	1 Each

3. TECHNICAL DATA AND SPECIFICATIONS

Ranging

6000 Series - Manual Selection of Four Ranges

6001 Series - Manual or Automatic Selection of Four Ranges

Range and Input Impedance

Range	Actual Range With Overrange	Maximum Input Impedance	10 Megohm Input Impedance
0-1 Volt	0-1.1999 Volts	*250 Megohms (Minimum at Full Scale)	10 Megohms
0-10 Volts	0-11.999 Volts	*500 Megohms (Minimum at Full Scale)	10 Megohms
0-100 Volts	0-119.99 Volts	10 Megohms	10 Megohms
0-1000 Volts	0-1199.9 Volts	10 Megohms	10 Megohms

Point of Automatic Ranging (6001 DVM)

Up-ranges at 120% of Full Scale

Down-ranges at 10% of Full Scale

Maximum Conversion Time

1 Millisecond Without Polarity or Change of Range (Constant regardless of input voltage magnitude.)

35 Milliseconds With Polarity Change

0.4 Second With Automatic Change of Range

*Full Scale Step-Input Response***

Range	Accuracy (With Respect to Final Reading	Response Time
1V	Within ±0.02%	80 Milliseconds
	Within ±0.05%	70 Milliseconds
10V	Within ±0.02%	50 ~~40~~ Milliseconds
	Within ±0.05%	5 Milliseconds
100V	Within ±0.02%	25 ~~50~~ Milliseconds
	Within ±0.05%	30 Milliseconds
1000V	Within ±0.02%	50 ~~40~~ Milliseconds
	Within ±0.05%	5 Milliseconds

**The maximum load current on the 1 volt range does not exceed 0.004 microamperes at any input level within the range. The maximum load current on the 10 volt range does not exceed 0.02 microamperes at any input level within the range.*

***Any source impedance $\leq$ 10,000 ohms.*

Display Rate

Internal Low Trigger - 1 to 3 Times/Second (Converts in 1 millisecond and displays from 332 to 999 milliseconds.)

Internal High Trigger - 50 or 60 times/second; depends directly on ac line frequency (converts in 1 millisecond and displays 15.7 milliseconds for 60 cps or 19 milliseconds for 50 cps line frequency).

Manual Trigger - Converts in 1 millisecond and displays until manual trigger pushbutton is depressed.

External Trigger - Dependent on externally selected rate via P4-50; up to 1000 times per second (can be triggered with internal 22-28 kc clock from P4-65). Fixed display obtained within 1 millisecond after applying -15 volt hold signal to P4-66.

NOTE

Above 100 conversions per second, the visual display will begin to show zeros in addition to the actual voltage reading. This is due to the decreased readout display time plus the increase in zero set sequences per second.

Accuracy

Calibrated to ±1 Digit Absolute Accuracy

Stability

The maximum absolute error is guaranteed not to exceed ±0.01% of full scale ±1 digit over a minimum period of 6 months. This statement assumes normal adjustment of the front panel ZERO control and does not include scale factor temperature coefficient (see following specification of zero drift).

Zero Drift

If the ZERO adjustment is set at a given temperature and is not re-adjusted with temperature change, the maximum zero drift is ±0.00175% of full scale/°C from the zero

set temperature. Zero drift due to temperature change can be removed by adjusting the ZERO control (on the front panel) before taking readings. (See Chapter 3, Paragraph 2*e.*)

Linearity

±0.0009% of Reading/°C Above or Below 25°C

Operating Temperature Range

10°C to 40°C

Power Requirements

105 to 125 VAC at 60 CPS; 123 VA at 117 VAC 60 CPS; 103 Watts at 117 VAC; 105 to 125 VAC at 50 CPS; 131 VA at 117 VAC 50 CPS.

Floating Input

Capable of floating dc inputs up to ±500 volts from ground*.

Warmup Time Requirement

20 minutes maximum.

Electrical Outputs and Programming Specifications

See Chapter 2, Tables 5 and 6.

Optional Programmable Input Filters

Both the 6000 and 6001 Series DVM Units are currently available with one of two variations of programmable input filters. See Paragraph 4 of this chapter.

**The DVM is normally operated with a floating input. If a chassis ground input connection is desired, the two outer shields of the three-conductor input cable must be connected together.*

4. OPTIONAL PROGRAMMABLE INPUT FILTERS

Variations of the basic 6000 and 6001 Series DVM's may be obtained with programmable input filter circuits. The filters are active types which may be electrically inserted or removed by means of a switch mounted on the rear panel of the DVM, or insertion and removal may be programmed via a remote circuit closure. DVM's containing these filters are variations of the basic units as follows:

a. 6000 Series, Model 26.257-1 and 6001 Series, Model 26.203-1

These DVM variations contain programmable filters which provide 40 db of common and normal mode noise rejection at 60 cps with an additional 12 db/octave above 60 cps. With the filter electrically in the circuit, the DVM settling time is 300 milliseconds.

b. 6000 Series, Model 26.257-2 and 6001 Series, Model 26.203-2

These DVM variations contain programmable filters which provide 60 db of common and normal mode noise rejection at 60 cps with an additional 12 db/octave above 60 cps. With the filter electrically in the circuit, the DVM settling time is one second.

CHAPTER 2

INSTALLATION AND ADJUSTMENTS

1. CHASSIS INSTALLATION

As previously indicated the DVM is designed for use as either a bench instrument or for rack mounting. Instruments for bench use are shipped complete and require no installation other than desired external connections. See Paragraph 2 of this chapter.

Unpack the DVM from the shipping carton, and check that all components are in place and undamaged (bench instruments should be slid out of the protective case). The unit may be removed from the case by removing the four screws which fasten the case to the DVM front panel and *two bottom screws* (Figure 3); slide the chassis forward out of the case.

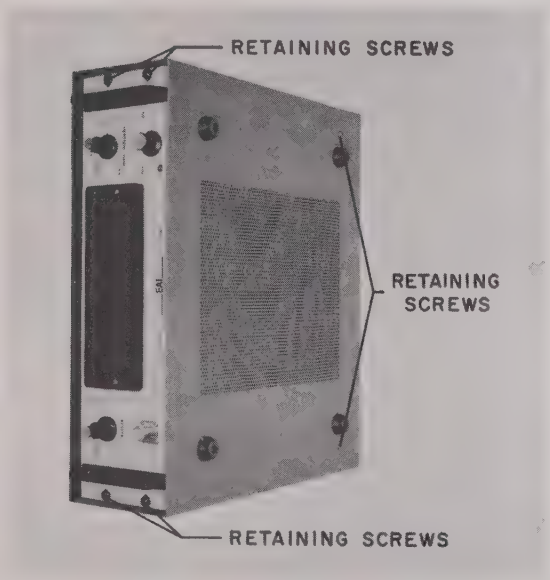


Figure 3. Cover Retaining Screw Location

If the DVM is to be rack mounted, the front panel should be fastened to the rack by running four screws (1/4-20 screws for EAI racks and 10-32 screws for a 19 inch RETMA rack) through the slotted holes on each side of the panel. *Secure these screws tightly.* Although the DVM chassis is sufficiently strong to permit rack-mounting without supporting the rear of the chassis, it is recommended that rear supports or side rails be installed in the rack. This will make the chassis easier to handle whenever removing the DVM from the rack.

2. AC POWER CONNECTION

The DVM is equipped with a standard 3-wire power cable for connection to a single-phase 115/230 volt 50/60 cps power source. If the power source is not wired for the 3-prong plug, an adaptor

is required. If the adaptor is used the ground lead (usually green) on the adaptor must be connected to an earth ground. Also, check the polarization of the ac line; ascertain that the DVM hot ac lead (black wire) is connected to the hot side of the ac source.

The 6000 and 6001 DVM's are designed for use with either 50 or 60 cycle power sources at 115 or 230 volts. Drawing D026 203 0S, Sheet 4 and D026 257 0S, Sheet 3 shows the units wired for 115 volt operation. For 230 volt operation the following wiring changes must be made:

(1) Remove the jumper between T1-2C and T1-2B.

(2) Remove the T1-1 end of the T1-1 to T1-2A jumper and re-terminate it at T1-2B.

(3) Change fuse F1 from 1.25 ampere to 3/4 ampere (indicate this change in lettering next to fuse holder).

(4) Change 117 vac lettering (next to power cable entry point on DVM rear panel) to 230 vac.

Primary ac power can also be applied via P4-76 (hot), P4-77 (common) and P4-78 (earth ground). These input terminations maintain the fuse in the input hot lead and also permit the continued use of the POWER ON/OFF/STANDBY switch (S4).

WARNING

Should ac power be applied via P4 the male contacts of ac power plug (P3) are exposed, unfused, and dangerous. The power cord should either be removed or some other foolproof precautions taken.

If the standard ac power cord input is used, ac power is then available at the P4 connector pins as follows: P4-76 hot, P4-77 common and P4-78 earth ground. Although P4 is a female-type connector caution should be exercised since this ac power is unfused.

3. EXTERNAL CONNECTIONS

Several connectors are mounted on the rear of the DVM chassis to provide for certain external control functions and electrical outputs. These connectors and their functions are described in the following paragraphs.

a. INPUT Connector

This coaxial jack (J2) is wired in parallel with an identical jack on the unit front panel (J1). (See Table 2, Chapter 1 for mating connector part number.)

b. TEST POINTS Connector P2

To facilitate adjustment and maintenance of the DVM certain input and output points are wired to this connector. The test points include all power supply voltage levels, amplifier output, and some logic-switching levels. In addition to the amplifier outputs, the outputs of the stabilizers of these amplifiers are also terminated at the TEST POINTS connector; this facilitates balancing these amplifiers as described in Chapter 3 of this manual. Table 7 in Chapter 5 lists the various signals available on the TEST POINTS connector and their levels or function. (See Table 2, Chapter 1 for mating connector part number.)

c. Connector P1

This 78 pin connector provides output signals and control functions to drive remote indicating devices, tape or card punches, or a printer. The following table briefly describes the available terminations. (See Drawings D026 203 0W and D026 257 0W.)

Table 5. Connector P1 Data Leads

Signal Description	Function	Electrical Characteristics
Decimal Data	0-9 Per Each Decade Counter (Plus 0 and 1 for 10,000's Counter)	-0.8* volt (at 5 ma) indicates presence of digit. -7 volts (at 1 ma) indicates absence of digit.
Overload/Range Indicator (6001 DVM Only)	Indicates overload on manual ranging and indicates when instrument is ranging in Automatic Range mode.	-0.8* volt (at 5 ma) indicates overload/ranging. -7.0 volts (at 1 ma) indicates no overload/ranging. See D026 203 0S.
Decimal Position (Range Indication)	1, 10, 100, or 1000 Volt Ranges	-0.8 volt level indicates meter range (at 5 ma). Other decimal position outputs at -7 volts (at 1 ma). See D026 203 0S (6001) and D026 257 0S (6000) Sheet 2.
Conversion Complete	Indicates End of Digitizing Process	Output level from +2* to -12 volts. Complement also available.

**Refers to saturated transistor in series with 4.7 ohm resistor.*

d. Connector P4

This connector primarily provides facilities for external control of the DVM; it also provides the BCD outputs. Table 6 briefly describes the available terminations. (See Drawing D026 203 0W or D026 257 0W.)

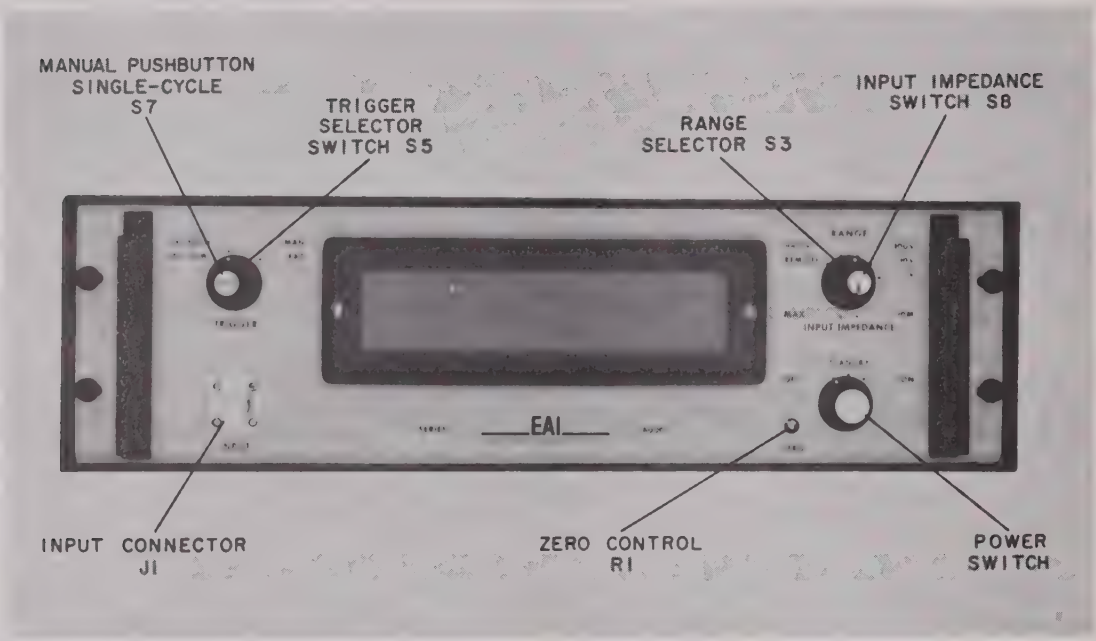
Table 6. Connector P4 Data Leads

Signal Description	Function	Electrical Characteristics
Binary-Coded Decimal	$\overline{1}, \overline{2}, \overline{4}, \overline{8}$ per each decade. Complement also available.	-12 volts indicates presence of bit. +2* volts indicates absence of bit.
Clock Output	22-28 KC Master Clock	-11 to 0 volt pulses of 10μ second duration, $<2\mu$ second.
Cycle Command Fast	50 or 60 CPS; depends on ac frequency. INT HIGH Clock	-11 to 0 volt pulses, $<1\mu$ second rise time, (8 milliseconds duration at 60 cps).
1 to 3 CPS Clock	INT LOW Clock	-12 to 0 volt pulses 10μ sec duration, $<1\mu$ sec rise time.
±Indicator	Indicates Input Polarity	-12 volts indicates polarity of input (at 0.5 ma). +2* volts indicates absence of polarity (at 1 ma). Complements also available.
Buffered Decimal Position (6000 DVM Only)	1, 10, 100, or 1000 Volt Ranges (Range Indicators)	-12 volts indicates meter range, other decimal terminations at +2 volts.
External Range Control	External Control of Range: Auto, 1V, 10V, 100V, and 1000V	Contact closure to remote switch position ground capable of handling 100 ma of current. See Chapter 4, Paragraph 4.
Hold Signal	External hold of display -- stops meter from further digitizing until released.	-12 volt (to -25 volt level: normally -15 volts) external source capable of delivering 1 ma of current. See Chapter 4, Paragraph 4.
External Trigger	External Cycle Command Control Signal	10 to 15 volt positive going pulse $\leq 5\mu$ second rise time. $\geq 20\mu$ second pulse width.

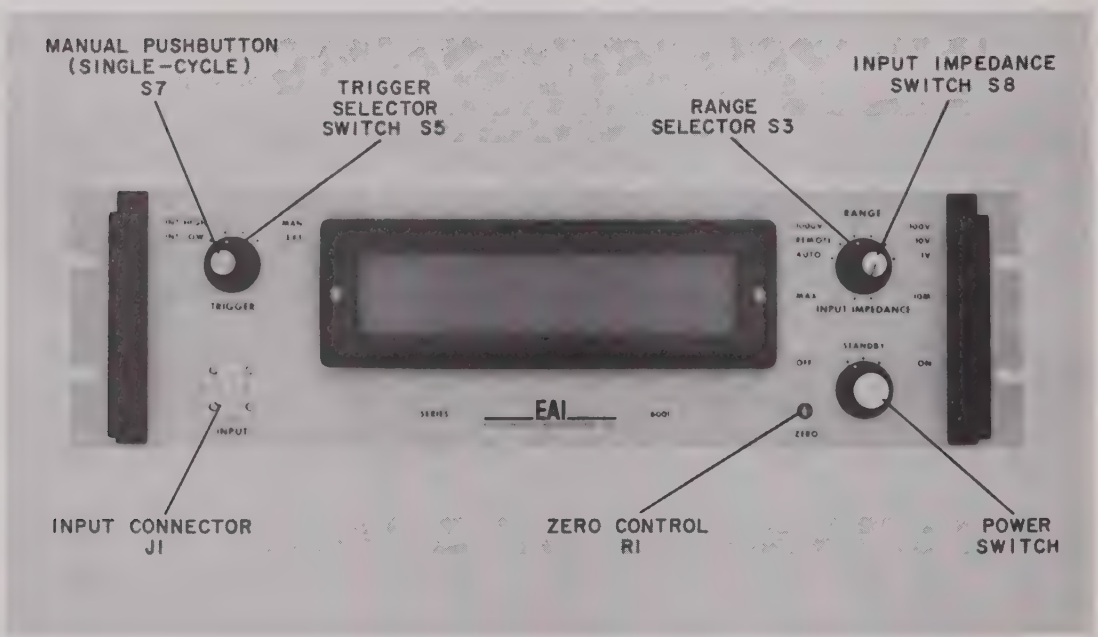
**Refers to saturated transistor.*

4. PRELIMINARY ADJUSTMENTS

Each DVM is completely checked and factory calibrated prior to shipment and should require no further adjustment upon receipt. A pre-operational check procedure is outlined in Paragraph 2 of Chapter 3 of this handbook. Performing this check will assure the operator that the instrument is operating properly. Should trouble be encountered, refer to the trouble check procedure in Chapter 5, Maintenance.



a. 6000 DVM



b. 6001 DVM

Figure 4. 6000 and 6001 DVM Controls

CHAPTER 3

OPERATION

1. CONTROL FUNCTIONS

When using the DVM the operator should be thoroughly familiar with all of the operating controls. The following is a list of the DVM operational controls with a brief description of the function of each. (All other controls or adjustments are considered as calibration controls and are described in Chapter 6, Calibration.) Control locations are shown in Figure 4.

Control	Function
POWER Switch S4	Three position rotary switch: STANDBY - Input signal lines are open, ground applied to dc amplifier input. All power circuit energized. ON - Ground removed from input to dc amplifiers; input signal leads connected to amplifier input. OFF - Input circuits open, all power off (ac input line opened).
RANGE Selector S3	Outer portion of dual control (S3 and S8). REMOTE - permits remote selection of ranges by remote contact closure (6000 and 6001) or selection of automatic ranging by remote contact closure (6001 only). AUTO - meter placed in automatic ranging mode of operation. 1000V, 100V, 10V, 1V - manual selection of indicated ranges.

Control	Function
TRIGGER Switch (Cycle Command Selector) S5	Outer portion of dual control (S5 and S7), four position rotary switch. EXT - Cycle (conversion) command pulse received from external source via P4-50. MAN - Cycle command received from MANUAL pushbutton switch S7, meter converts once each time button is depressed. INT HIGH - Conversion commands generated internally at 50 or 60 cps rate (directly dependent on ac line frequency). INT LOW - 1 to 3 conversion commands per second internally generated.
MANUAL Pushbutton (S7)	Inner portion of dual switch (S5 and S7). Provides single conversion command pulse each time pushbutton is depressed. Meter completes one conversion cycle and holds readout until button is again pushed.
INPUT IMPEDANCE Switch (S8)	Inner portion of dual switch (S3 and S8). Two position switch; in 10M position all four ranges have identical 10 megohm input impedances. In MAX position unloading circuits are switched into the 1 volt and 10 volt range circuits providing extremely high input impedances for those ranges.
ZERO Control (R1)	Screwdriver adjustment to permit zero-setting of the indicators.

2. PRE-OPERATIONAL CHECKS

The procedures outlined in this paragraph are recommended for use as a pre-operational check and for periodic preventive maintenance purposes after the instrument has been in service. The checks are relatively simple to perform and serve to indicate that the instrument is functioning properly. The tests do not, however, check the instrument accuracy. An accuracy test procedure is provided in Chapter 5, Maintenance.

a. Prepare the DVM for operation and set the POWER switch to STANDBY; allow 20 minutes for warm up. (The TRIGGER switch should be on INT HIGH.)

b. Connect a multimeter (Triplett, Model 630A or equivalent) between pins 1 (reference amplifier stabilizer output) and 16 (ground) of TEST POINTS connector P2. The meter should fluctuate about zero ±0.05 on the 3 volt range*. If the meter does not read within these limitations adjust R9 on the 6.736 Reference Amplifier Card.

CAUTION

Relatively high levels of voltage may be generated as the BAL control is rotated. Use high voltage ranges first reducing to the 3-volt range as the voltage null is approached.

c. Connect the multimeter between pins 16 and 17 of the TEST POINTS connector (stabilizer output of Amplifier "A"). If the meter does not read zero ±0.05 volts adjust R10 on the 12.937 Network Card.

d. Repeat Step *c.* connecting the meter between 16 and 18 (stabilizer output of amplifier "B"). Adjust R11 on the 12.937 Network if necessary.

e. Set the RANGE switch to the 10 volt position (with the POWER switch in STANDBY) and adjust the ZERO control (Figure 4) until the indicators display either + or -00.000. (If the polarity relay begins to chatter turn the ZERO control slightly clockwise until the chatter stops and the indicators retain the plus or minus 00.000 display.)

f. Connect a low-level variable dc voltage source (capable of supplying potentials of 0 to ±12 volts) to the input connector; set the DVM RANGE switch of the 6001 to the AUTO position; use the 10 volt range for the 6000. (The dc source must be stable.)

g. Set the dc source for a positive output of less than 1 volt. Slowly vary the input voltage and check for proper counting sequence. Make sure that the digits in each decade are displayed in proper order. (Check that the 6001 DVM changes to the next higher range when the input is raised above 1.1999 and 11.999 volts.) Reverse the input polarity; observe that the polarity indicator changes.

**The meter needle vibrates since the stabilizer output at this test point is pulsating dc.*

h. Connect a stable high-level, variable dc voltage source to the input connector. Alternately apply inputs of 90 volts of each polarity; check for proper ranging and polarity indication. Repeat for a voltage greater than 120 volts (up to 1000 volts).

i. Manually switch the 6001 DVM to the 10 volt range. Apply a positive or negative voltage of less than 10 volts to the DVM and slowly increase this potential. Observe that the overload lamp starts to flicker as the input raises above 11.999 volts.

If the DVM operates as described in the preceding steps and no troubles are encountered, the instrument is functioning properly. If the unit is used with an external triggering source, or with a unit which supplies a hold voltage, etc., a simple test run should be performed on the overall system operation.

3. NORMAL OPERATION

Normal operation of the 6000 DVM and the 6001 DVM is relatively simple using the controls described in Paragraph 1; however, certain precautions should be observed.

a. When the 6001 DVM range is manually selected and the INT HIGH trigger (or an external trigger rate greater than 50 cps) is used, overloads $\geq$ 500 volts applied to the instrument on either the 1 or 10 volt ranges may permanently damage the precision input resistor network.

b. When the 6001 DVM range is manually selected and the INT LOW or MAN trigger modes are used, an overload of $\geq$ 300 volts applied to the instrument on either the 1 or 10 volt ranges may permanently damage the precision input resistor network.

c. When the 6001 DVM is in the AUTO RANGE mode and the INT LOW, MAN or an external trigger less than 50 cps is used, a voltage $\geq$ 300 volts may damage the precision input resistors if the instrument starts on the 1 or 10 volt range.

d. Should an overload be applied to the 6001 DVM when the MAN (or an external single-cycle command) trigger mode is used and the range manually selected the following sequences of events occur. The DVM will up-range to the 1000 volt range thus lighting the overload lamp; however, the DVM digitizes while on the 1000 volt range (due to relay drop out time) prior to reverting to the manually selected range. The DVM remains in the manual range, with the overload lamp out and *the overrange voltage still applied,* until the manual trigger pushbutton is again pushed (or the external single cycle command generated). Failure to

correct this condition when the instrument is on the 1 or 10 volt range may damage the precision input resistor if a substantial overload exists. (Even if the momentary lighting of the overload lamp is not observed, this condition can be recognized by the very low magnitude of the display.)

e. The precision input resistors of the 6000 Series DVM may be permanently damaged any time a voltage $\geq$ ~~300~~ 120 volts is applied to either the ~~1 or~~ 10 volt ranges.

NOTE

As implied in the above paragraphs, the standard voltmeter operating technique of always starting on the highest meter range when measuring an unknown voltage level will prevent possible damage to the precision input resistors.

CHAPTER 4

THEORY OF OPERATION

1. INTRODUCTION

This chapter describes the theory of operation of the DVM in terms of a block diagram and a functional diagram analysis. The operation is initially described for a sampling cycle without range (magnitude) or polarity change, the automatic ranging and polarity relay circuits are described separately. All descriptions are supplemented by block diagrams, simplified schematics, a timing diagram, functional diagrams, logic diagrams and a power distribution diagram. Transistor theory and standard circuits incorporating these devices *are not* described in detail since much written material is available on these subjects.

The 6000 and 6001 Series DVM's utilize the programmed-comparison type of meter circuit where the current produced by the unknown (or input) voltage is compared to a known current which is the BCD equivalent of the analog unknown; decoding the BCD count to the decimal equivalent provides a decimal display of the unknown magnitude. Polarity detection circuits provide a display of the polarity sign.

2. BLOCK DIAGRAM DESCRIPTION

Figure 5 is a block diagram illustrating the operation of the DVM; it illustrates the 6001 DVM specifically. The 6000 DVM block diagram differs only in the absence of the *auto range circuit;* thus, the recycle command, up/down range instructions and overrange indicator signal leads are also absent.

The unknown input is applied to the dual dc amplifiers and input circuits which provide the high impedance of the meter as well as scaling of the unknown input. The input system consists of two cascaded operational amplifiers. The first amplifier has a series of relay controlled input and feedback resistors which determine the gain. The selection of the input and feedback resistor determines the scale factor applied to the unknown input and thus determines the meter range. The actual selection of the meter range, via the range relay operation, may be automatically (6001 only) or manually controlled. The second amplifier has a fixed gain-of-one. The two amplifiers provide both a positive and a negative polarity scaled representation (equal in magnitude) of the input unknown. Both polarities of the scaled unknown are applied to the polarity relay K1.

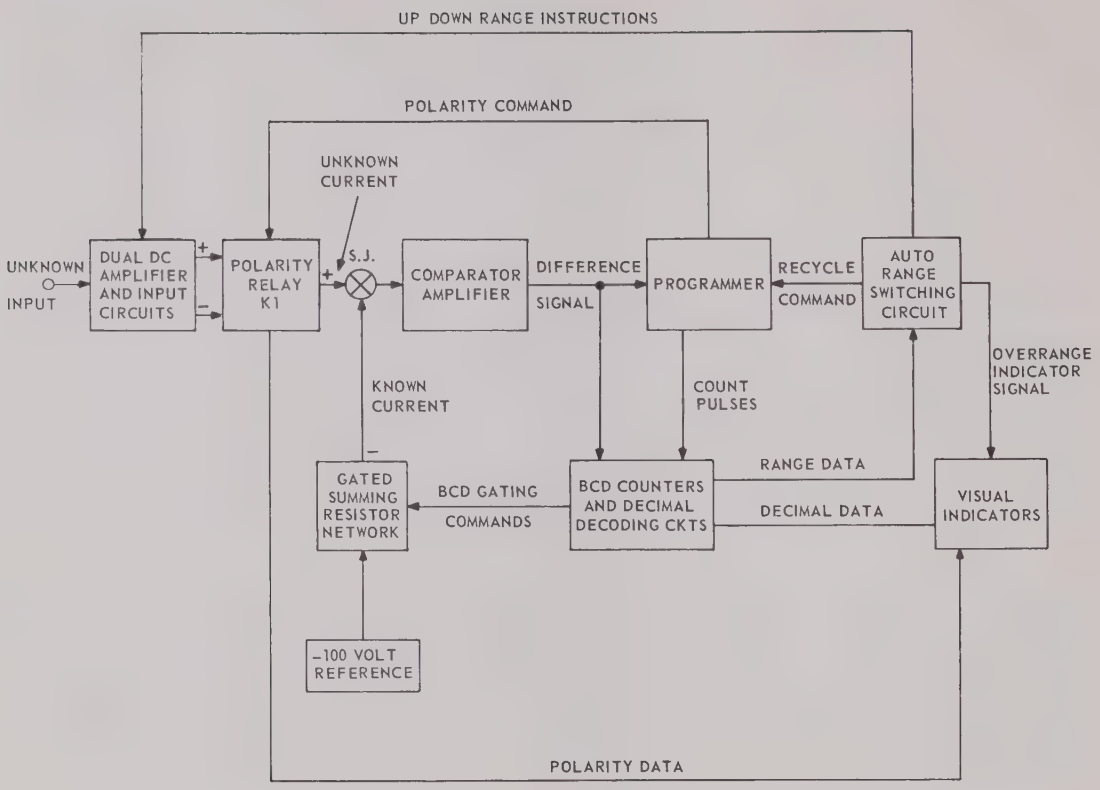


Figure 5. 6001 Digital Voltmeter Block Diagram

The state of the polarity relay is always set to provide the positive scaled representation of the unknown to the comparator summing junction since it is to be compared to a known current generated by a negative voltage source. Since the polarity of the unknown input determines which of the two amplifiers will provide the scaled positive signal and the polarity relay is always switched to select this positive potential, the state of the polarity relay is used to display the proper polarity indication on the visual readout.

The proper state of the polarity relay is determined by the programmer. The programmer temporarily removes all of the known current from the comparator summing junction thus placing the comparator input entirely under the influence of the scaled unknown input as selected from one of the two input amplifiers. The comparator output level indicates to the programmer whether the scaled unknown is of positive or negative polarity: if the comparator output is negative the relay state is retained; if the comparator output is positive the relay is switched to its opposite state. Once the polarity relay is properly set, the programmer starts

the comparison sequence by sending counting instructions to the binary-coded decade (BCD) counters. There are four cascaded BCD counters each controlling the gates of a set of weighted resistors; each resistor set controls current flow from a known negative voltage source in BCD steps. In addition each set of resistors differs by an order of magnitude in the BCD steps of current they will pass to the comparator summing junction. Thus, on count instruction from the programmer, the BCD counters release the gates of the weighted resistor sets and apply current from the negative source in known BCD steps. This is compared to the current from the scaled positive representation of the unknown input.

The counters release the current through the most significant bit weighted resistor of the highest order resistor group first. Then the next most significant resistor gate is opened and then the next and so on through the highest order gates. The next highest order counter then releases its most significant weighted resistor gate.

As each gate is opened the comparator indicates to the BCD counters whether the current from the known or from the unknown source is the largest. If the unknown current is larger the opened gate remains opened (it's counter remains ON) when the next gate is released. If the known current is larger the gate is closed (it's counter is turned OFF) when the succeeding gate is opened. Using this programmed-comparison sequence of operation, the known and unknown currents are brought into agreement in magnitude.

The counters that are still ON when agreement is reached (and the counting cycle is completed), contain in BCD count, the magnitude of the unknown input. This data is decoded into the decimal form and displayed as the magnitude of the unknown input on the visual readout.

The auto range circuit of the 6001 DVM only enters into the sequence of operation under the following conditions: when the meter is in the auto-range mode of operation and is on too high or too low a range, or if the meter is in the manual range selection mode of operation and an overrange input voltage is applied to the meter.

In the auto-range selection mode of operation, the auto-range circuits monitor the BCD counters. If the highest order BCD counter registers a count over eleven, it indicates the meter is on too low a range, and up-range instructions are applied to the relays controlling the gain of the first input amplifier. The auto-range circuit also sends a re-cycle command to the programmer and the counting sequence re-starts with the meter in the new range. A similar sequence of operation is followed if the highest order counter registers a zero count; this indicates the meter is on too high a range. The auto-range circuits in this case instruct the input circuit to down-range to the next lower range and the programmer is sent a recycle command.

When the range is manually selected the auto-range circuit of the 6001 cannot change the selected range permanently; it does, however, act as an overload protection circuit. In this case the auto-range circuit only responds to the highest order BCD count when it exceeds an eleven count. This, like in the auto-range operation, causes the auto-range circuit to up-range the DVM and recycles the programmer. Since the meter range was manually selected, however, the meter will return to the selected range on the recycle command. Unless the range is manually changed or the overload removed, the meter will again try to up range. Thus, with an overload input, the meter cycles between the selected range and the up ranged state.

The overload duty cycle that the meter is subjected to is of an extremely short duration and normally will not cause damage to the input circuit. This *overload* condition is visually indicated by a red dot on the visual readout indicator. (The red dot is always illuminated when the meter ranges, however, it only lights momentarily and does not continuously flash as in an overload condition.)

3. CIRCUIT DESCRIPTION

Functional Schematic Diagrams D026 203 0S, Sheets 1 through 3 (6001 DVM) and D026 257 0S, Sheets 1 and 2 (6000 DVM), both bound in Appendix II, are used as the basis of the DVM circuit description. These diagrams are supplemented by a logic flow-diagram, a timing diagram, and several simplified schematics.

Initially the DVM circuit operation is described without a range change; thus covering both the 6000 and 6001 DVM's. The auto range circuit and its operation in the 6001 DVM is covered subsequently in the text.

In order to enable the reader to more easily follow the logic operations of the DVM, the dual dc amplifier input circuits, and the comparator amplifier and gated resistor matrix are first described.

a. Input Amplifier Circuits

Figure 6a is a simplified schematic of the input amplifier circuit of the DVM. Diagrams b through e of Figure 6 illustrate the various input and feedback combinations (selected via relays K2 and K3) which provide the DVM with its four input ranges. The relay control circuits are described later in the text in conjunction with the range control circuits (Sub-paragraph *d*).

The dual amplifier configuration permits the DVM to measure both positive and negative inputs and also provides the continuous high input impedance of this unit. Note that the gain of amplifier A changes by an order of magnitude for each range; thus at full scale on any range the out-

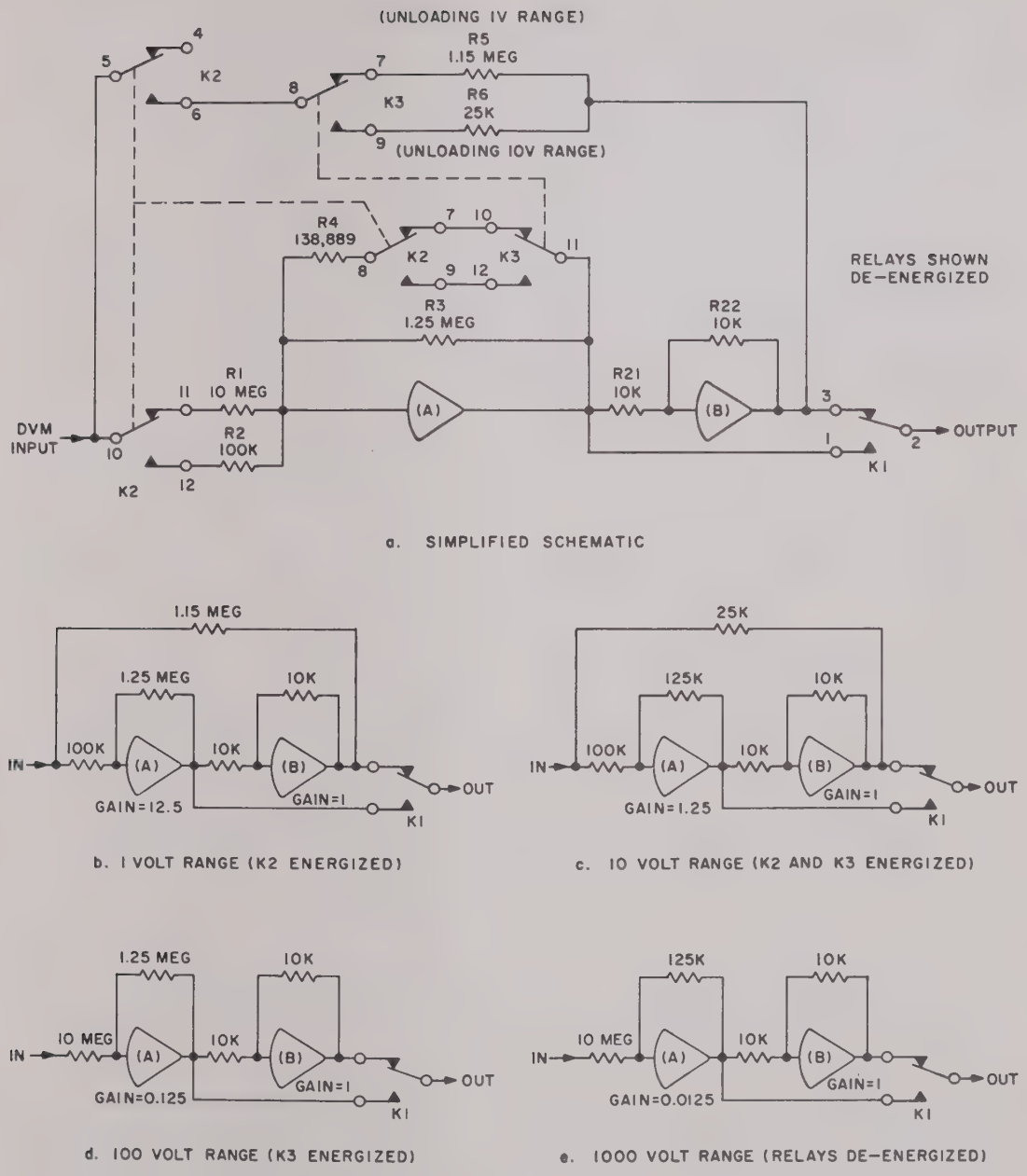


Figure 6. Input Amplifier, Simplified Schematics

put of amplifier A is 12.5 volts. The gain of amplifier B is fixed at 1 in all cases; thus, contacts 1 and 3 of relay K1 will always have opposite polarity but equal magnitude scaled representations of the input unknown. During the *sign check* sequence in the DVM operation (described later in the text) the position of the K1 armature is determined so the positive scaled representation of the unknown is applied to the comparator summing junction.

The dual dc amplifiers therefore, provide the scaling for the four meter ranges, provide the continuous high input impedance, and provide scaled representations of both polarities so a positive representation of the input may be applied to the comparator summing junction. A gain greater than 1 is provided so that the 1 and 10 volt ranges can be unloaded. (The unloading circuits are shown in simplified form in Figure 6.)

An anti-saturation network (shown schematically on Drawing C012 937 0S) is provided to prevent saturation of amplifier A during overload conditions. This decreases the amplifier recovery time to overload conditions.

b. Comparator Amplifier and Gated Resistor Matrix

The comparator amplifier is a high gain unit sensitive to the polarity of the source of the comparator summing junction current. It consists of a four stage differential amplifier (Q1 through Q4 of the 26.240) and two cascaded output stages, Q5 and Q6. The output stages operate at either saturation (0 volts out) or at cut-off (-14 volts out) in response to the polarity of the summing junction current source; the output of Q5 is the COMP + line and that of Q6 the COMP - line. The two outputs are opposite in phase. (Since the DVM only uses the COMP - output it will simply be referred to hereafter in the text as the comparator output.)

The comparator output is negative (-14 volts) when the comparator summing junction current is due to a positive polarity source and this output is positive (0 volts) when the summing junction current is due to a negative polarity source.

In addition to the output of one of the dual dc amplifiers, the gated resistor matrix is also connected to the comparator summing point (Figure 7). The gated resistor matrix is provided with a -100 volt reference source. Thus the polarity of the comparator output indicates whether the current due to the unknown at the summing junction is larger (-14 volts or negative comparator output) or if the matrix current is larger (positive comparator output).

The current from the negative reference source is divided into binary-coded decimal steps by the use of matched resistor sets. A typical example is illustrated in Figure 7 which shows

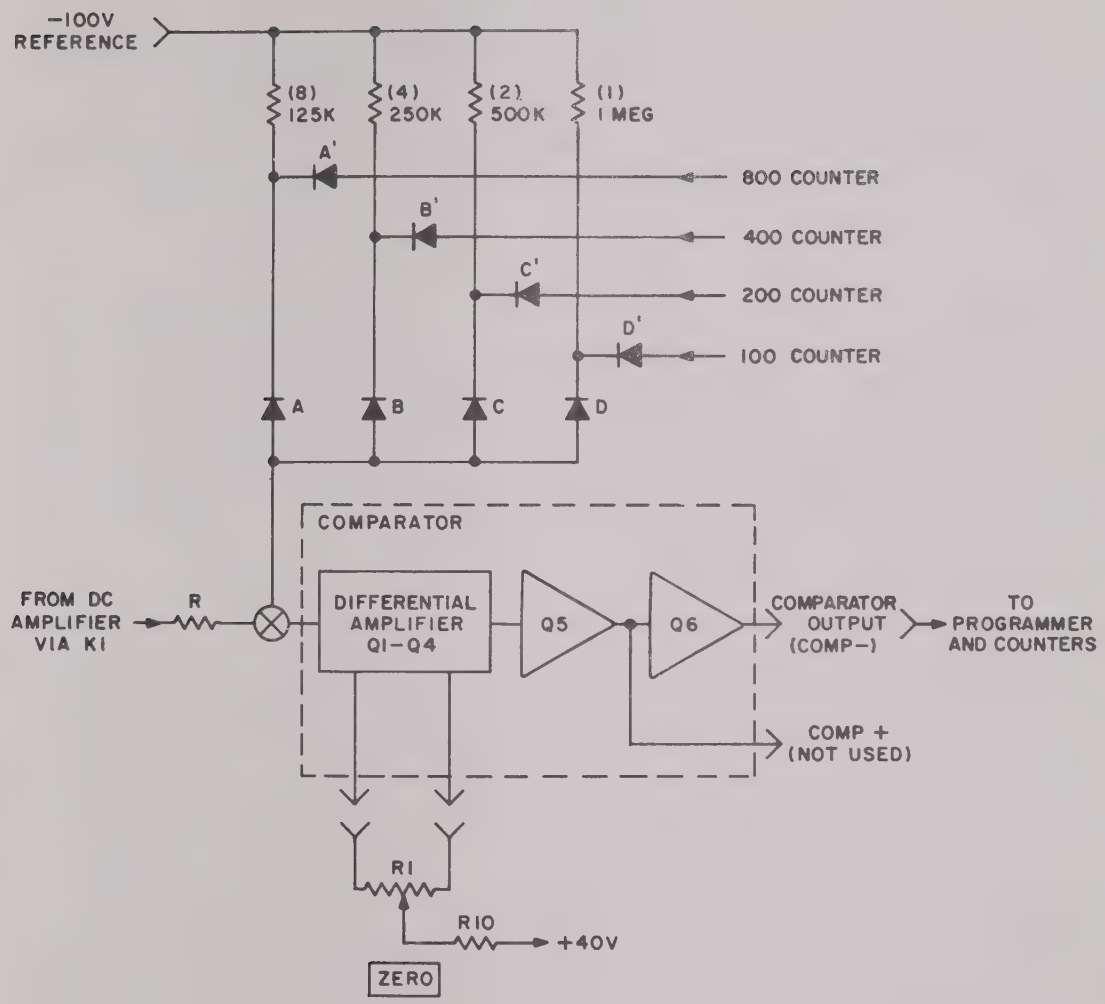


Figure 7. Comparator and Typical Gated Resistor Matrix, Simplified Schematic

four resistors, each gated, and each gate controlled by a separate BCD counter. (The BCD counters of the 100's decade are shown in this illustration.) The 125K resistor permits eight times the current flow as the 1 megohm and so on in the ratio of 8 : 4 : 2 : 1 as indicated by the parenthetical notations in Figure 7. If three more sets of these resistors, each set ratioed to the other by an order or more in magnitude, are added to this group and controlled by the 1000's, 10's, and 1's counter, then the BCD count of each decade of the DVM will determine a precise current flow from the negative source to the comparator summing point.

The current from -100 volt reference source is compared to that from the positive representation of the unknown input at the comparator. The larger of the two in determining the comparator polarity output permits the DVM to bring the reference current into agreement with the unknown current. When this state is attained the count in the BCD decades is a numerical equivalent of the unknown input magnitude. The polarity of the unknown is also known as described later in the text.

The counters control the reference current flow to the comparator summing junction by either forward biasing or reverse biasing the diode gates of the resistor matrix. For example, if the 800 counter applies a +2 volt potential to diode A' of Figure 7, diode A is reversed biased and the current through the 125K resistor cannot reach the comparator summing point. If the 800 counter applies a -10 volt potential to A', then A' is reverse biased and the current through the 125K resistor flows through diode A to the comparator.

c. DVM Operating Cycle (Without Ranging)

The following logic description covers the overall operation of the DVM during a sampling cycle of the unknown input. This description assumes as previously mentioned that the polarity of the input does not change, nor is up or down ranging of the 6001 DVM required. This description divides the operating cycle into three parts: zero set and polarity check, digitizing cycle (these two parts of the operating cycle make up the conversion cycle), and the display cycle.

To make the description meaningful assume the DVM has sampled and is reading out an input potential of +45.07 volts just prior to starting a new conversion cycle. Figure 8 is a timing diagram of the DVM operation showing waveforms at various points throughout the unit. (Portions of the diagram are exaggerated for clarity and all waveshapes are idealized.) The diagram is divided into time increments across the top in relationship to the fast (hereafter refined to as the *master*) clock pulses generated by oscillator Q11-Q12 on the 44.271 Programmer. The frequency of the master clock is between 22 kc and 28 kc; for this description each time interval is assumed to be 45 microseconds. The one exception is the time increment between t_0 and t_0'. The t_0' is the time at which a conversion command pulse is received; since there is generally no synchronization between the master clock and this command it is assumed t_0 and t_0' do not coincide.

(1) *Zero Set and Polarity Check.* Figure 9 (Part I) is a logic flow diagram of the zero set and polarity check portion of the DVM conversion cycle. The hexagon shaped block indicates interconnections between diagram parts; like numbers form a continuous path. Diamond shaped blocks are *decision* blocks indicating where a choice of two conditions may occur; the decisions

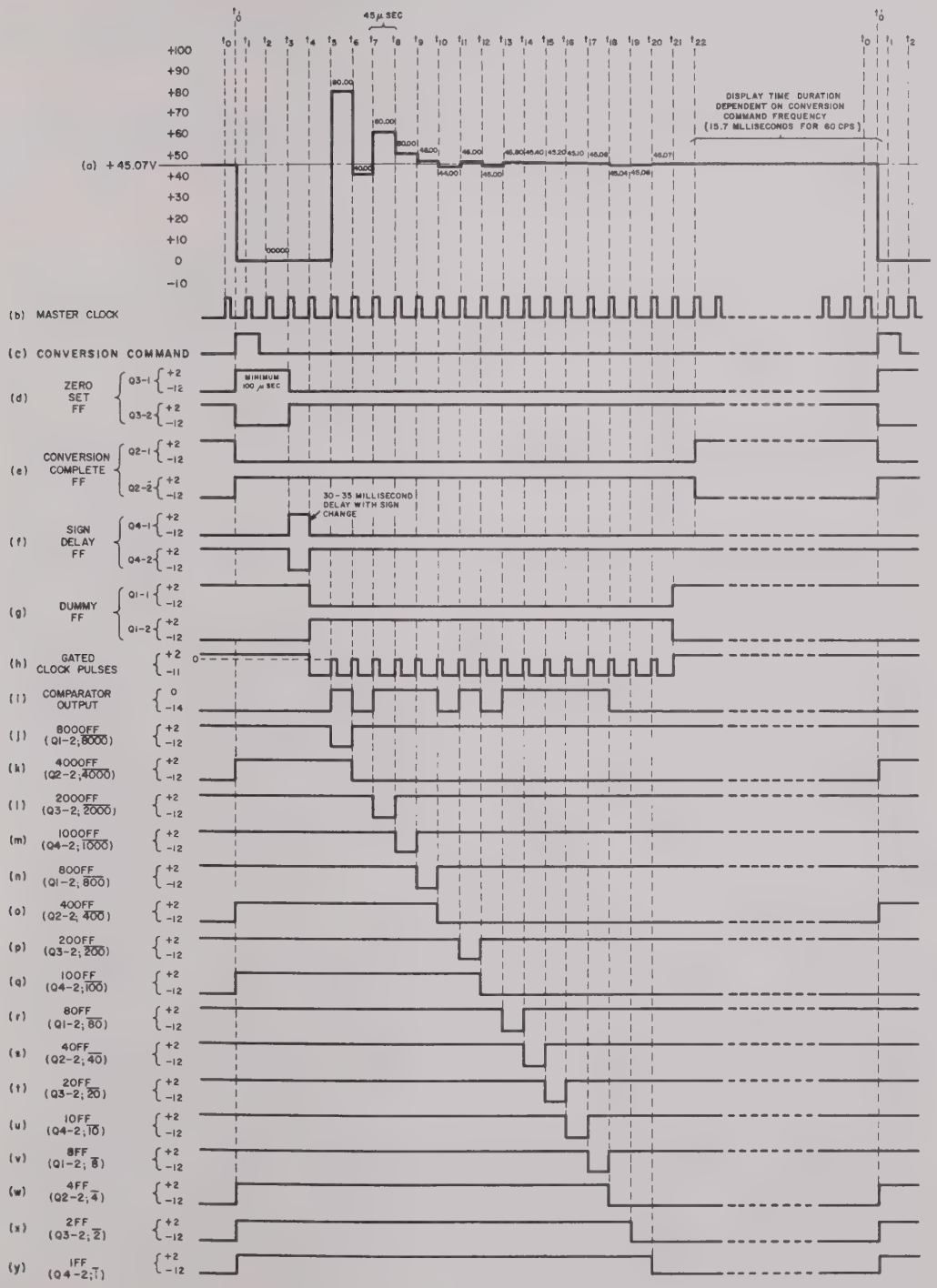


Figure 8. DVM Timing Diagram

made by the DVM are for the most part dependent on the state of the comparator output. The rectangular blocks are *event* blocks which briefly describe the equipment operations; these are generally determined by the previous decision.

The quiescent states of the bistable multivibrators of the programmer are as follows: (The levels listed in parenthesis are idealized.)

1. Dummy Flip-Flop: Q1-1 on (+2); Q1-2 off (-12)
2. Conversion Complete Flip-Flop: Q2-1 on (+2); Q2-2 (-12)
3. Zero Set Flip-Flop: Q3-1 off (-12); Q3-2 on (+2)
4. Sign Delay Flip-Flop: Q4-1 off (-12); Q4-2 on (+2)
5. Sign Flip-Flop: the state of this flip-flop is dependent on the polarity of the unknown input; if Q5-1 is on (+2) the relay driver Q6 conducts and K1 is energized (input unknown is negative), if Q5-1 is off (-12) then Q6 is cut off and K1 de-energizes (input is positive).

Note that the Figure 9 diagram starts with the conversion command pulse and is immediately followed by a decision block regarding the completion of the previous conversion cycle. If the previous conversion cycle (which only includes the zero set-polarity check, and the digitizing cycle, not the display cycle) is not complete the Conversion Complete flip-flop will inhibit the triggering of the Zero Set flip-flop (provided the conversion command is not greater than 12 volts in magnitude; D044 271 0S, Appendix II). The DVM will not start a conversion cycle until a new conversion command is received and the Conversion Complete flip-flop is back to its quiescent state.

Figure 8 assumes the Conversion Complete flip-flop is in the quiescent state at t'_0 when the conversion command is received. The answer to the first decision, therefore, is yes and the conversion command pulse triggers the Zero Set flip-flop. As indicated, the Zero Set flip-flop resets all the BCD counters to Zero and triggers the Conversion Complete flip-flop.

The zero setting of the BCD counters removes all reference current from the comparator summing point, thus the comparator summing junction is controlled by the scaled unknown representation. The output of the comparator indicates if the scaled unknown is of the proper polarity for the digitizing operation (positive scaled unknown). After a 100 microsecond delay the next clock pulse triggers the Zero Set flip-flop to its original state. The delay assures removal of all reference current from the comparator and that the comparator output has responded to the unknown polarity. (This is necessary since the conversion command pulse is not necessarily

synchronized with the 22-28 kc clock and a clock pulse occurring immediately following the conversion command pulse would otherwise reset the Zero Set flip-flop.)

If the comparator output is negative it indicates that a positive scaled representation of the unknown is being applied to the comparator. If the comparator output is positive, the scaled unknown on the comparator summing junction is negative and relay K1 must be set to the opposite state.

In either case, the next clock pulse, after the 100 microsecond delay, resets the Zero Set flip-flop which in turn triggers the Sign Delay flip-flop. If the state of the K1 relay must be changed, the resetting of the Zero Set flip-flop also triggers the Sign flip-flop to its opposite state. The sign relay changes state and selects the output of the two input amplifiers that will provide the scaled position representation of the unknown input. The Sign flip-flop when it is triggered, triggers the Sign Delay monostable multivibrator. The Sign Delay mono provides a 30 to 35 millisecond delay (by preventing the Sign Delay flip-flop from resetting) to permit the K1 relay to change state.

If the K1 relay is in the proper state, the resetting of the Zero flip-flop triggers the Sign Delay flip-flop as previously indicated but the comp out level (-14 volts) inhibits the triggering of the Sign flip-flop.

After the delay of the sign circuit, a minimum of one microsecond without a sign change and 30 to 35 milliseconds with the sign change, the next clock pulse resets the Sign Delay flip-flop to its quiescent state, The resetting of the Sign Delay flip-flop triggers the Dummy flip-flop to its opposite state.

The Dummy flip-flop sends an enable signal to the 8 counter flip-flop in the 1000's decade and also releases count pulses (master clock pulses) to all of the counters. The triggering of the Dummy flip-flop starts the digitizing process of converting the dc analog input magnitude to the binary-coded decimal equivalent.

Each conversion cycle is started by triggering the Zero Set flip-flop. The Zero Set flip-flop, however, returns to its quiescent state after about 100 microseconds, should it be triggered again it would probably stop the conversion cycle the DVM has started and restart with a new cycle without determining the input magnitude. To prevent such false starts, the Conversion Complete flip-flop inhibits the Zero Set flip-flop conversion command input. The Conversion Complete flip-flop is inhibited from resetting first by the Zero Set flip-flop itself, then the Sign Delay flip-flop when the Zero Set flip-flop is reset, and finally by the Dummy flip-flop when the Sign Delay flip-flop is reset. Since the Dummy flip-flop remains set until the digitizing cycle is complete, the Zero Set flip-flop cannot be triggered until the magnitude of the input is determined.

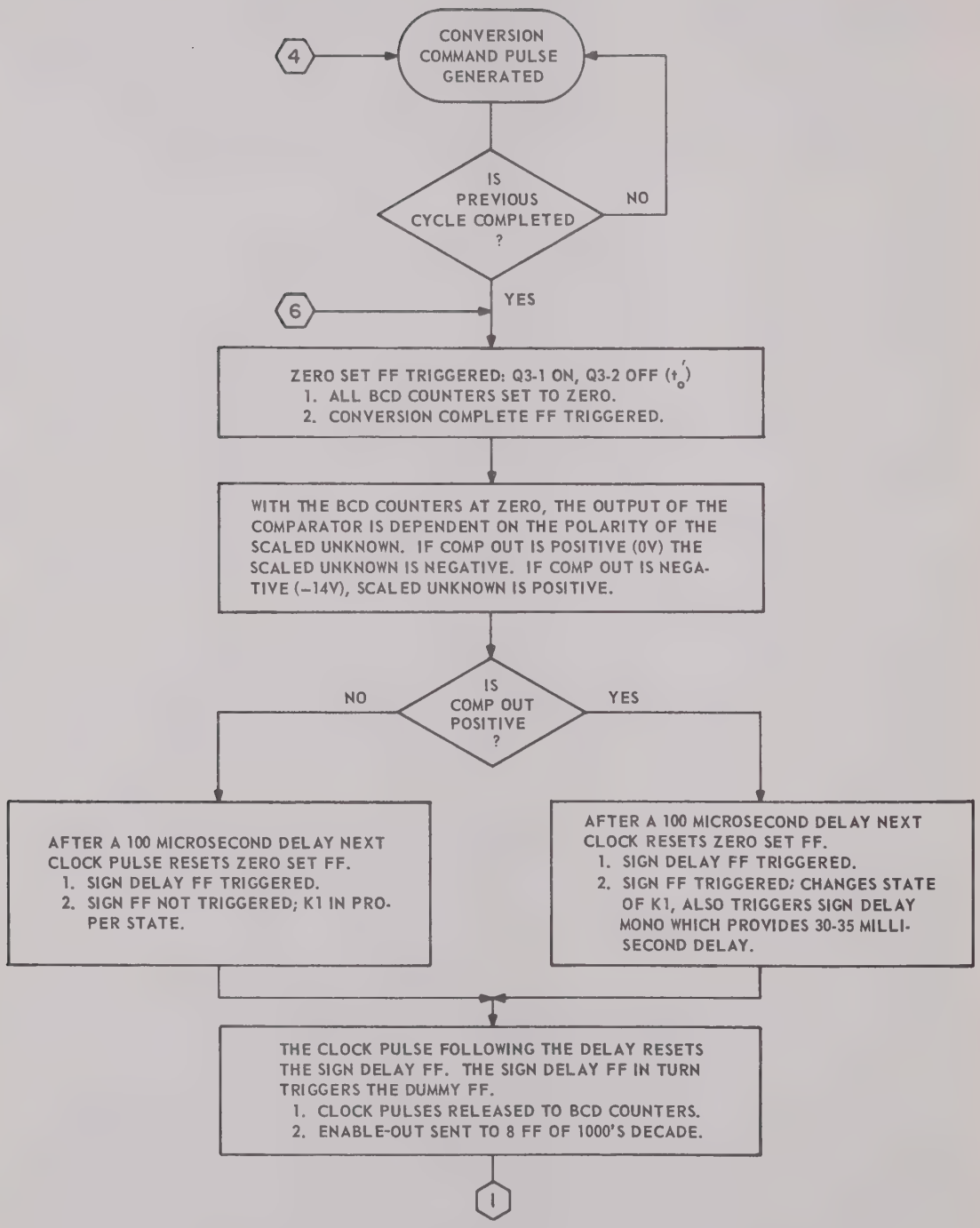

4
CONVERSION COMMAND PULSE GENERATED
IS PREVIOUS CYCLE COMPLETED ?
NO
6
YES
ZERO SET FF TRIGGERED: Q3-1 ON, Q3-2 OFF (t_o')
1. ALL BCD COUNTERS SET TO ZERO.
2. CONVERSION COMPLETE FF TRIGGERED.
WITH THE BCD COUNTERS AT ZERO, THE OUTPUT OF THE COMPARATOR IS DEPENDENT ON THE POLARITY OF THE SCALED UNKNOWN. IF COMP OUT IS POSITIVE (0V) THE SCALED UNKNOWN IS NEGATIVE. IF COMP OUT IS NEGATIVE (–14V), SCALED UNKNOWN IS POSITIVE.
IS COMP OUT POSITIVE ?
NO
YES
AFTER A 100 MICROSECOND DELAY NEXT CLOCK PULSE RESETS ZERO SET FF.
1. SIGN DELAY FF TRIGGERED.
2. SIGN FF NOT TRIGGERED; K1 IN PROPER STATE.
AFTER A 100 MICROSECOND DELAY NEXT CLOCK RESETS ZERO SET FF.
1. SIGN DELAY FF TRIGGERED.
2. SIGN FF TRIGGERED; CHANGES STATE OF K1, ALSO TRIGGERS SIGN DELAY MONO WHICH PROVIDES 30-35 MILLISECOND DELAY.
THE CLOCK PULSE FOLLOWING THE DELAY RESETS THE SIGN DELAY FF. THE SIGN DELAY FF IN TURN TRIGGERS THE DUMMY FF.
1. CLOCK PULSES RELEASED TO BCD COUNTERS.
2. ENABLE-OUT SENT TO 8 FF OF 1000'S DECADE.
1

Figure 9. (Part I) DVM Logic Flow Diagram (Zero Set and Polarity Check)

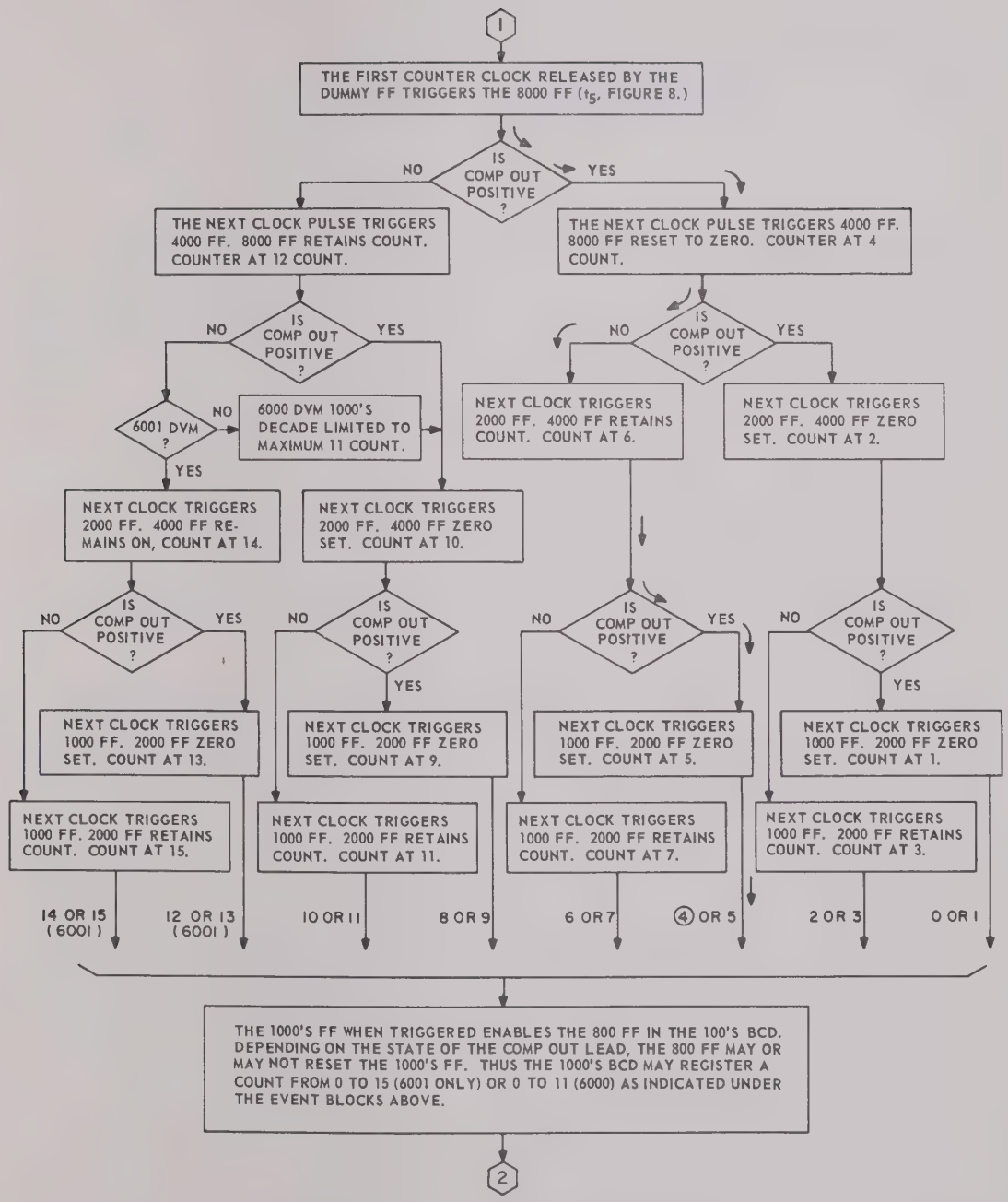

1
THE FIRST COUNTER CLOCK RELEASED BY THE DUMMY FF TRIGGERS THE 8000 FF (t_5, FIGURE 8.)
IS COMP OUT POSITIVE ?
NO
YES
THE NEXT CLOCK PULSE TRIGGERS 4000 FF. 8000 FF RETAINS COUNT. COUNTER AT 12 COUNT.
THE NEXT CLOCK PULSE TRIGGERS 4000 FF. 8000 FF RESET TO ZERO. COUNTER AT 4 COUNT.
IS COMP OUT POSITIVE ?
6001 DVM ?
6000 DVM 1000'S DECADE LIMITED TO MAXIMUM 11 COUNT.
NEXT CLOCK TRIGGERS 2000 FF. 4000 FF RETAINS COUNT. COUNT AT 6.
NEXT CLOCK TRIGGERS 2000 FF. 4000 FF ZERO SET. COUNT AT 2.
NEXT CLOCK TRIGGERS 2000 FF. 4000 FF REMAINS ON, COUNT AT 14.
NEXT CLOCK TRIGGERS 2000 FF. 4000 FF ZERO SET. COUNT AT 10.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF ZERO SET. COUNT AT 13.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF ZERO SET. COUNT AT 9.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF ZERO SET. COUNT AT 5.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF ZERO SET. COUNT AT 1.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF RETAINS COUNT. COUNT AT 15.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF RETAINS COUNT. COUNT AT 11.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF RETAINS COUNT. COUNT AT 7.
NEXT CLOCK TRIGGERS 1000 FF. 2000 FF RETAINS COUNT. COUNT AT 3.
14 OR 15 (6001)
12 OR 13 (6001)
10 OR 11
8 OR 9
6 OR 7
④ OR 5
2 OR 3
0 OR 1
THE 1000'S FF WHEN TRIGGERED ENABLES THE 800 FF IN THE 100'S BCD. DEPENDING ON THE STATE OF THE COMP OUT LEAD, THE 800 FF MAY OR MAY NOT RESET THE 1000'S FF. THUS THE 1000'S BCD MAY REGISTER A COUNT FROM 0 TO 15 (6001 ONLY) OR 0 TO 11 (6000) AS INDICATED UNDER THE EVENT BLOCKS ABOVE.
2

Figure 9. (Part II) DVM Logic Flow Diagram (1000's BCD Operation)

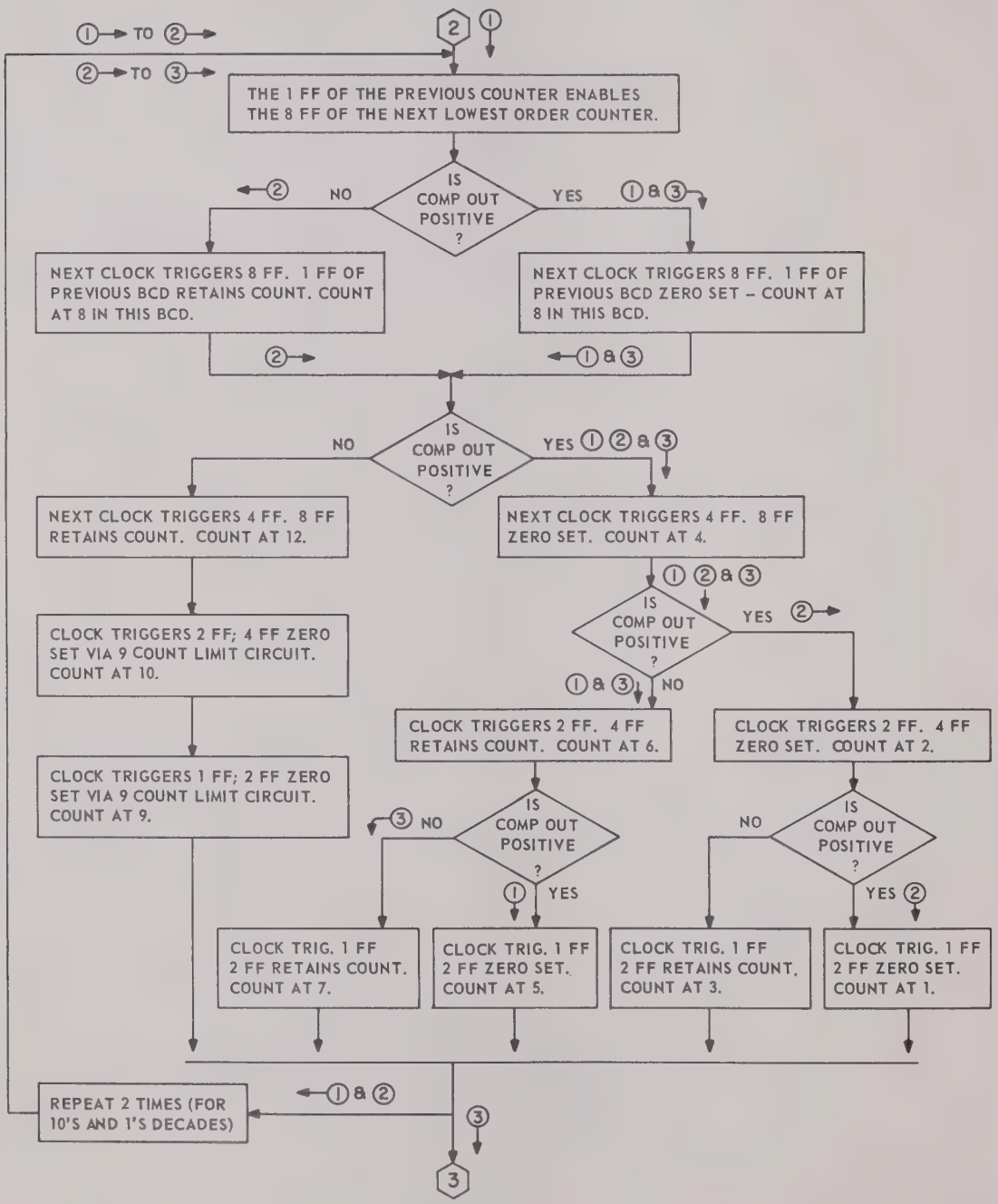

① → TO ②
② → TO ③
2
①
THE 1 FF OF THE PREVIOUS COUNTER ENABLES THE 8 FF OF THE NEXT LOWEST ORDER COUNTER.
IS COMP OUT POSITIVE ?
NO
② ←
YES
① & ③ →
NEXT CLOCK TRIGGERS 8 FF. 1 FF OF PREVIOUS BCD RETAINS COUNT. COUNT AT 8 IN THIS BCD.
NEXT CLOCK TRIGGERS 8 FF. 1 FF OF PREVIOUS BCD ZERO SET – COUNT AT 8 IN THIS BCD.
② →
← ① & ③
IS COMP OUT POSITIVE ?
NO
YES ① ② & ③
NEXT CLOCK TRIGGERS 4 FF. 8 FF RETAINS COUNT. COUNT AT 12.
NEXT CLOCK TRIGGERS 4 FF. 8 FF ZERO SET. COUNT AT 4.
① ② & ③
CLOCK TRIGGERS 2 FF; 4 FF ZERO SET VIA 9 COUNT LIMIT CIRCUIT. COUNT AT 10.
IS COMP OUT POSITIVE ?
YES ②
① & ③
NO
CLOCK TRIGGERS 2 FF. 4 FF RETAINS COUNT. COUNT AT 6.
CLOCK TRIGGERS 2 FF. 4 FF ZERO SET. COUNT AT 2.
CLOCK TRIGGERS 1 FF; 2 FF ZERO SET VIA 9 COUNT LIMIT CIRCUIT. COUNT AT 9.
③ NO
IS COMP OUT POSITIVE ?
① YES
NO
IS COMP OUT POSITIVE ?
YES ②
CLOCK TRIG. 1 FF 2 FF RETAINS COUNT. COUNT AT 7.
CLOCK TRIG. 1 FF 2 FF ZERO SET. COUNT AT 5.
CLOCK TRIG. 1 FF 2 FF RETAINS COUNT. COUNT AT 3.
CLOCK TRIG. 1 FF 2 FF ZERO SET. COUNT AT 1.
REPEAT 2 TIMES (FOR 10'S AND 1'S DECADES)
← ① & ②
③
3

Figure 9. (Part III) DVM Logic Flow Diagram (100's, 10's and 1's BCD Operation)

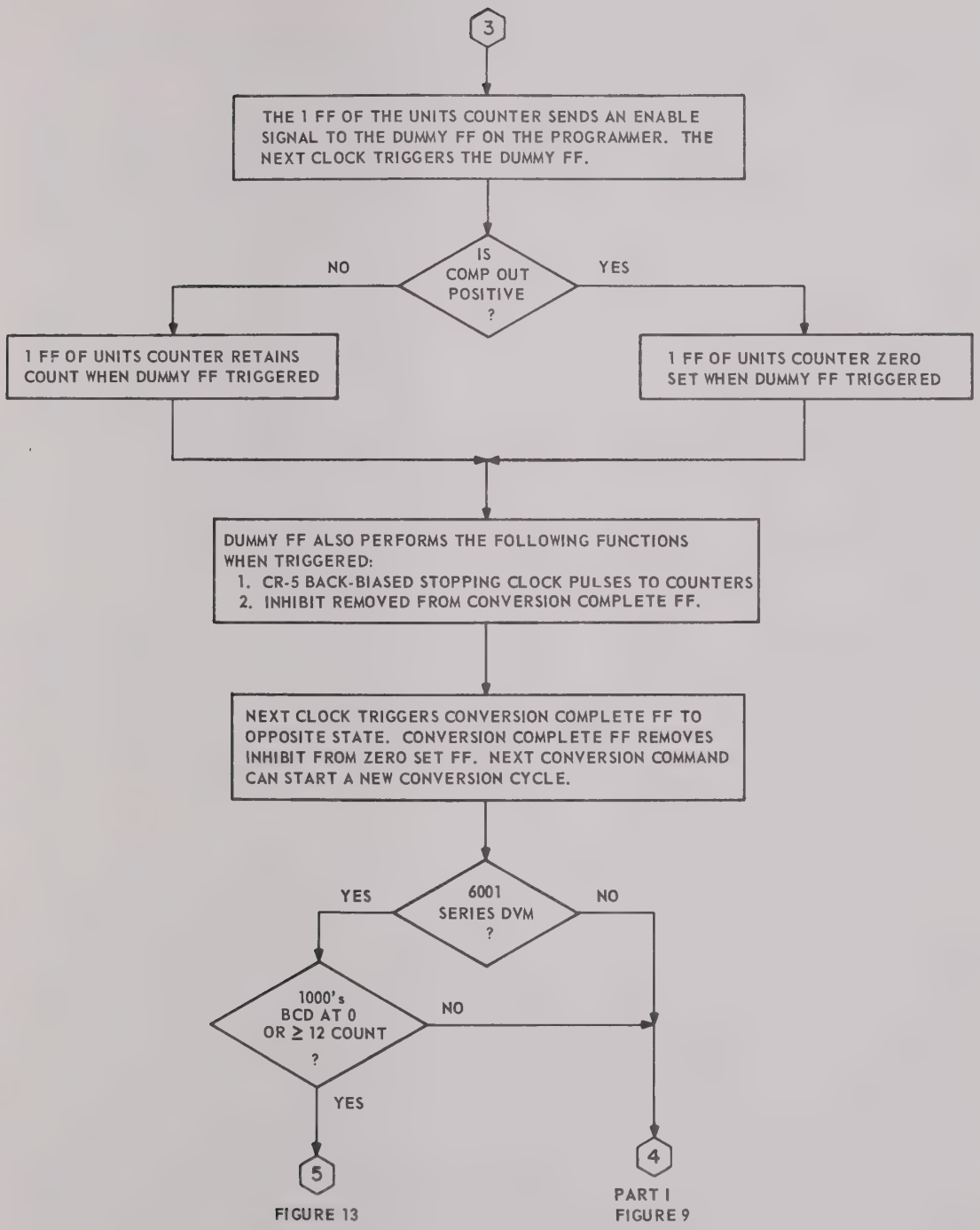

3
THE 1 FF OF THE UNITS COUNTER SENDS AN ENABLE SIGNAL TO THE DUMMY FF ON THE PROGRAMMER. THE NEXT CLOCK TRIGGERS THE DUMMY FF.
IS COMP OUT POSITIVE ?
NO
YES
1 FF OF UNITS COUNTER RETAINS COUNT WHEN DUMMY FF TRIGGERED
1 FF OF UNITS COUNTER ZERO SET WHEN DUMMY FF TRIGGERED
DUMMY FF ALSO PERFORMS THE FOLLOWING FUNCTIONS WHEN TRIGGERED:
1. CR-5 BACK-BIASED STOPPING CLOCK PULSES TO COUNTERS
2. INHIBIT REMOVED FROM CONVERSION COMPLETE FF.
NEXT CLOCK TRIGGERS CONVERSION COMPLETE FF TO OPPOSITE STATE. CONVERSION COMPLETE FF REMOVES INHIBIT FROM ZERO SET FF. NEXT CONVERSION COMMAND CAN START A NEW CONVERSION CYCLE.
6001 SERIES DVM ?
YES
NO
1000's BCD AT 0 OR ≥ 12 COUNT ?
NO
YES
5
FIGURE 13
4
PART I FIGURE 9

Figure 9. (Part IV) DVM Logic Flow Diagram (Completion of Conversion Cycle)

The state of K1 indicates the unknown polarity: if energized the unknown is negative, if de-energized the unknown is positive. One set of contacts of K1 are used to light the proper polarity indicator.

Thus the Zero Set and sign check portion of the DVM conversion cycle is started when the Zero Set flip-flop is triggered setting the counters to zero. Resetting the Zero Set flip-flop triggers the Sign Delay flip-flop and Sign flip-flop (if relay K1 is in the wrong state). The Sign flip-flop in turn triggers the Sign Delay mono. The Sign Delay mono delays the operating sequence to provide operating time for the sign relay (K1). On completion of the sign check, and relay state change if required, the Sign Delay flip-flop is reset, triggering the Dummy flip-flop which begins the digitizing portion of the conversion cycle.

(2) *Digitizing Cycle.* The digitizing cycle starts when the Dummy flip-flop releases the inhibit gate (diode CR1, Drawing D044 271 0S) and permits the clock pulses to be sent to the BCD counters. The Dummy flip-flop also sends an enable signal to pin 22 of the 1000's counter (Drawing D038 027 0S and Figure 10) and releases the differentiator (via CR4-1) in the trigger input lead of transistor Q1-2 of the 8 flip-flop in the 1000's counter (or 8000's flip-flop).

At time t_5 of Figure 8, which assumes no polarity or range change, (curve h) the first such clock pulse is sent out of the programmer to pin Y of the 1's BCD. It is shunted through this counter via CR7 and output Z, to pin Y of the 10's counter, through CR7 and out Z and so on to pin Y of the 1000's decade. In the 1000's decade this clock pulse also passes through CR7 and then through the released differentiator in the base circuit of Q1-2 triggering the 8000's flip-flop to the one state (as indicated by the first event block of Figure 9, Part II).

Assuming the DVM is in the 100 volt range and measuring +45.07 volts as indicated by Figure 8 (curve a), the 8000's flip-flop will release reference current equivalent to 80.00 volts in magnitude to the comparator summing junction. The 8000's flip-flop in triggering also releases the differentiator in the base circuit of Q2-2 of the 4000's counter (via CR4-2 and back biases diode CR6-1 and CR7 via CR5-1. Back biasing these diodes prevents the next clock pulse from reaching the 8000's flip-flop.

The 8000's flip-flop in releasing current proportional to 80.00 volts takes control of the comparator summing junction and causes the comparator output level to swing positive. The comparator output lead is brought into each decade counter via pin 20 (Comp in). In this case the positive Comp in signal releases the differentiator between the collector of Q2-1 (4000's flip-flop) and diode CR2-1 in the base circuit of Q1-1 (8000's flip-flop). Thus, as indicated by the arrows on Figure 9, Part II, when the next clock is received and triggers the 4000's flip-flop, the 8000's flip-flop is reset to zero removing its 80.00 volt current level from the comparator.

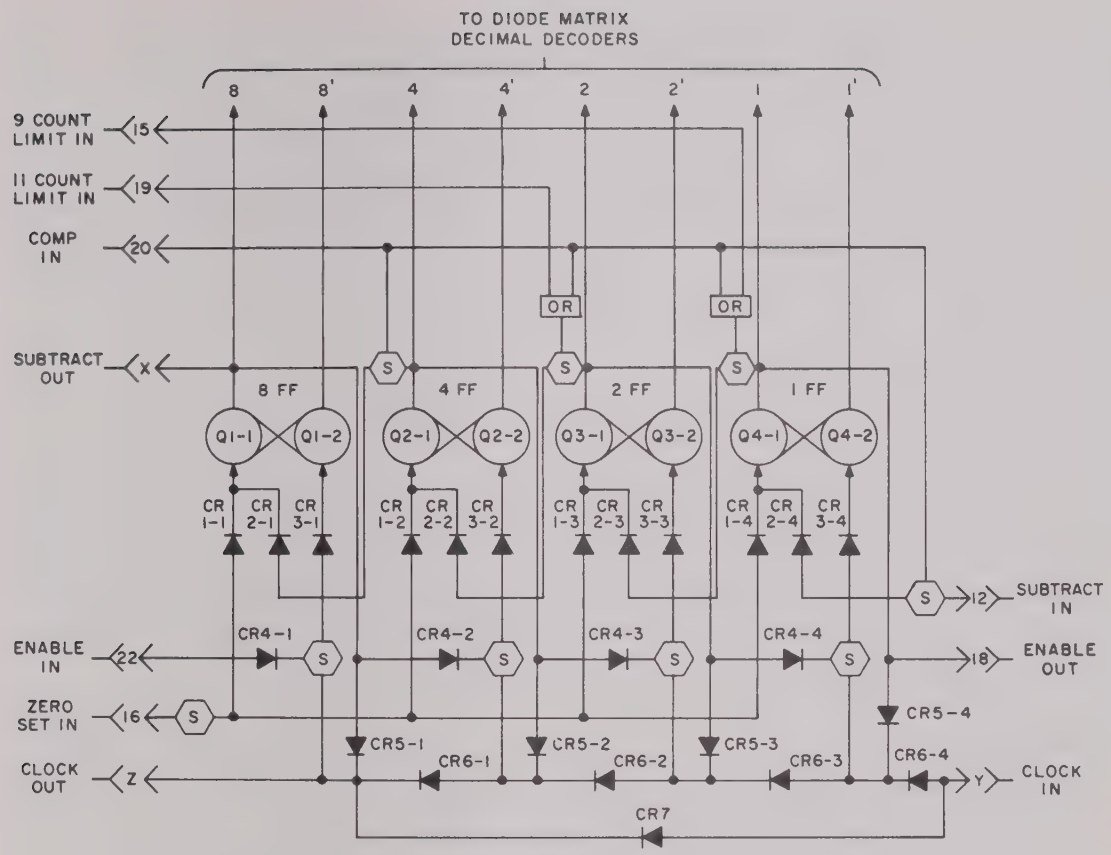


Figure 10. Typical BCD Counter Circuit

The 4000's flip-flop, however, releases current porportional to 40.00 volts to the comparator. Since this is less than the unknown current (45.07 volts) the comparator output swings negative. Thus the differentiator between the 2000's flip-flop and the 4000's flip-flop is inhibited and when the 2000 flip-flop is triggered by a clock pulse at t_5 the 4000's flip-flop remains in the ON state. The count continues in a similar manner to the 1000's flip-flop; in this example the 2000's flip-flop is reset to zero so the counter contains a five count when the 1000's flip-flop is triggered.

With the 4000's and 1000's flip-flop's in the ONE state reference current proportional to 50.00 volts is applied to the comparator causing the comparator output to swing positive. This releases the differentiator in the base circuit of Q4-1 (1000's flip-flop); this differentiator is connected to the 800's flip-flop via pin 12 of the 1000's decade to pin X (subtract out) of the 100's decade. Thus when the 800's flip-flop triggers, the 1000's flip-flop is zero set. The 1000's

flip-flop initially enables the 800's flip-flop differentiator (via pin 18 of the 1000's decade and pin 22 of the 100's) so the 800's flip-flop can trigger.

As indicated on Figure 9, Part II, with the 1000's flip-flop in the ONE state the 1000's decade may contain counts of 1, 3, 5, 7, 9, or 11 (the 6001 can also contain counts of 13 or 15). Depending on the state of the comparator output the 1000's flip-flop may or may not be zero-set when the 800's flip-flop triggers. Thus, as indicated *under* the event blocks are the possible *resultant counts* (from 0 to 15) when the 800's flip-flop triggers (inside the event blocks are the possible counts with the 1000's flip-flop ON). The 12 to 15 count of the 6001 is over the meter range (indicates 120 to 150 volts), however, this data is used by the automatic ranging circuits. The circled 4 indicates the final count of the 1000's counter for the assumed +45.07 volt input. Figure 9, Part III, illustrates the operation of the 100's, 10's, and 1's counters. The operation of these counters is similar except their count is limited to a maximum of 9. This is accomplished simply by jumpering pins 15, 19 and X of each individual counter. Thus if the 8 flip-flop is in the ONE state and the 4 flip-flop does not reset it to ZERO, the 2 flip-flop automatically zero sets the 4 flip-flop via the differentiator enabled by the 8 flip-flop through pin 19. In the same manner, the 1 flip-flop automatically zero sets the 2 flip-flop (if the 8 flip-flop is on) via the differentiator enabled via pin 15.

The path indicated by the circled 1 is the sequence of events of the 100's counter with the DVM measuring +45.07 volts. The circled 2 and 3 indicate the sequence of events taking place in the 10's and units counters respectively.

If the 1000's decade contains a count of 12 or greater or a count of 0 when the 400's flip-flop is triggered, the automatic ranging circuits take control of the DVM operation. This sequence is described in Sub-paragraph *d*.

The programmer Dummy flip-flop acts as a Counter flip-flop with respect to the 1's decade 1 flip-flop. As shown on Figure 9, Part IV, the 1's flip-flop enables the Dummy flip-flop; when the Dummy flip-flop triggers it sends a subtract pulse to the 1 flip-flop which zero sets this flip-flop if the comparator output is positive. In this example where the DVM is measuring +45.07 volts the 1's flip-flop remains in the ONE state.

The Dummy flip-flop also indicates the end of the conversion cycle. When triggered it also back biases diode CR-5 on the programmer preventing any further clock pulses from reaching the counters. It also removes the inhibit signal from the Conversion Complete flip-flop. The next clock pulse resets the Conversion Complete flip-flop, thus ending the conversion cycle. As indicated on Figure 9, Part IV, the reset Conversion Complete flip-flop removes its inhibit signal from the Zero Set flip-flop and returns the event sequence to Figure 9, Part I.

In summary, the digitizing cycle starts with the enabling of the 8000's flip-flop by the Dummy flip-flop. Each counter is triggered in sequence starting with the 8000's flip-flop and on to the 1's flip-flop. As each flip-flop triggers it releases reference current to the comparator summing junction in proportion to the flip-flop order of magnitude. The reference current is continually compared to the scaled-unknown current and by trial and error the flip-flop counts are either retained or reset to ZERO until the scaled unknown and reference currents are in agreement. The Dummy flip-flop then stops the counting procedure and the Conversion Complete flip-flop is triggered indicating the end of the conversion cycle. The DVM is then ready to recycle (t_{22}, Figure 8).

(3) *The Display Cycle.* The length of the display cycle is dependent on the frequency of the conversion command pulse source. For example, if the INT LOW trigger is used (1 to 3 cps) the display time will be from 332 to 998 milliseconds, if the MANUAL trigger is used the display time is indefinite, i. e., the DVM displays the readout until the TRIGGER pushbutton is again pushed. The DVM can also be triggered by the master clock, in this case the readout is displayed for a maximum of 45 microseconds (one clock pulse after the triggering of the Conversion Complete flip-flop). In this latter case visual readout is impossible. However, within a maximum of one millisecond after applying a hold voltage (-15 volts) to P4-66 a fixed readout is displayed.

The readout display essentially starts at time t_{20} when the Conversion Complete flip-flop triggers; at this time the final count of the BCD decades is determined. Actually the decoding matrix which controls the light drivers responds to each change in BCD count, however, since each decade is completed in 190 microseconds or less the lamp filaments do not have time to respond to each count change. In addition, since the entire conversion cycle is completed in 1 millisecond and the minimum display time with the INT HIGH trigger (and a 60 cps ac line frequency) is 15.7 milliseconds the readout will appear as a continuous display (assuming a stable input). With a 50 cps line frequency, using the INT HIGH trigger, the display time of the readout is 19 milliseconds.

Figure 11 illustrates the logic circuits of the BCD decades for converting the BCD count to the common decimal equivalent. (This illustration also shows the display lamp drivers.) Drivers Q7 and Q8 with the associated AND gates are only required for the 1000's counter to permit registering an 11 count. For this same reason Q17 and Q18 are OR gated to permit them to indicate the proper digit when the count is 0, 1, 10 or 11. All four BCD cards have this overrange capability and any one may be placed in the 1000's decade position or vice versa. (The 1000's card should be returned to its own position, A5; since this unit is used to drive two lamps at all times, continuous use in one of the other positions may have adverse effects on the display lamp life.)

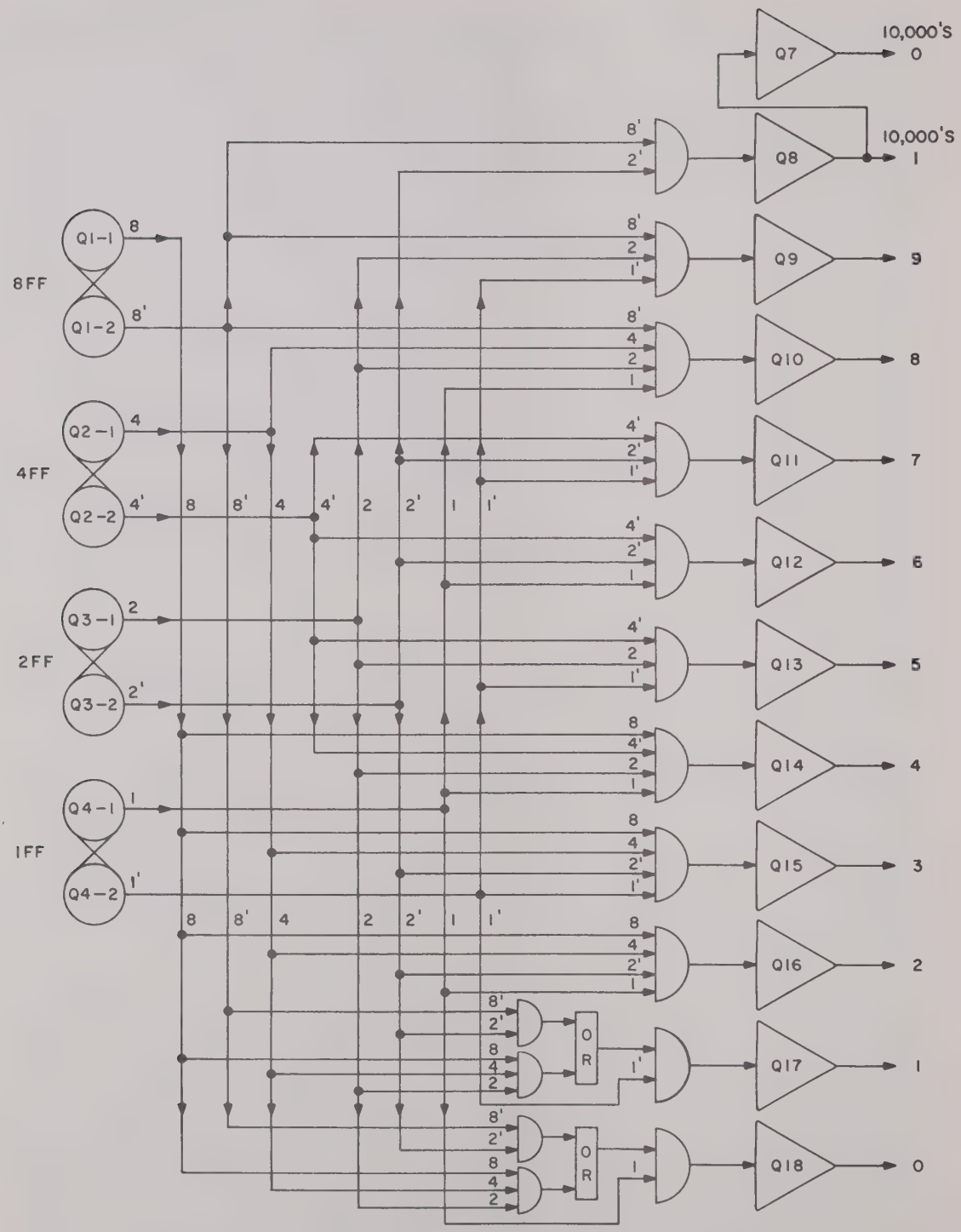


Figure 11. Decoding Matrix and Light Drivers, Logic Diagram

The AND gates of Figure 11 consists of diodes which in the forward biased state prevent the corresponding lamp driver from illuminating the associated lamp. As an example of the decoding operation assume the counters of Figure 11 have registered a binary 6 count. The collectors of transistors Q1-1 (8 flip-flop), Q2-2 (4 flip-flop), Q3-2 (2 flip-flop) and Q4-1 (1 flip-flop) are negative for a 6 count. These negative potentials are applied to the various diode AND gates of Figure 12. Note that the only AND gate with all negative inputs is the gate associated with Q12 the 6 lamp driver.

d. Automatic Ranging Circuits (6001 Series Only)

The automatic range switching circuit is capable of performing two separate functions, depending on the operating mode of the DVM (automatic or manual range selection modes). In the automatic range selection mode (selected either locally or remotely) the circuit seeks and selects the lowest range capable of measuring a given input voltage (excluding 20% overrange capability when down ranging). When a range is selected manually, the auto range circuits acts as an overload protection circuit to prevent damage to the precision input circuits. (Caution, however, should be exercised when the DVM is in the MAN or EXT trigger modes since the instrument cannot sense an overrange input until triggered to start a conversion cycle.)

The first two sub-paragraphs describe down ranging and up ranging respectively with respect to automatic ranging. The third sub-paragraph describes the manual range selection overload protection operation.

(1) *Down Range Circuit.* Figure 12 is a simplified logic diagram of the down range portion of the 14.201 Automatic Range Switching Circuit. (Portions of this circuit are common to the up range circuit.) The overall schematic diagram is shown on Drawing D014 201 0S in Appendix II.

The state of relays K2 and K3 determines the gain of the input amplifier A as illustrated by Figure 6. Relays K2 and K3, when the DVM RANGE switch is in the AUTO position, function in response to the gray code counter consisting of flip-flop Q1-1 and Q2-1, and flip-flop Q1-2 and Q2-2. As indicated by the table on Figure 12, whenever the right-hand side of either of these flip-flop's (Q2-1 and Q2-2) is cut off their corresponding relays are energized. The table lists the state of these transistors (approximate collector levels are +2 volts at conduction and -12 volts at cut off) for each of four meter ranges. To change ranges it is necessary to change the status of the gray code counter. Figure 13 is a logic flow diagram for the auto range circuit.

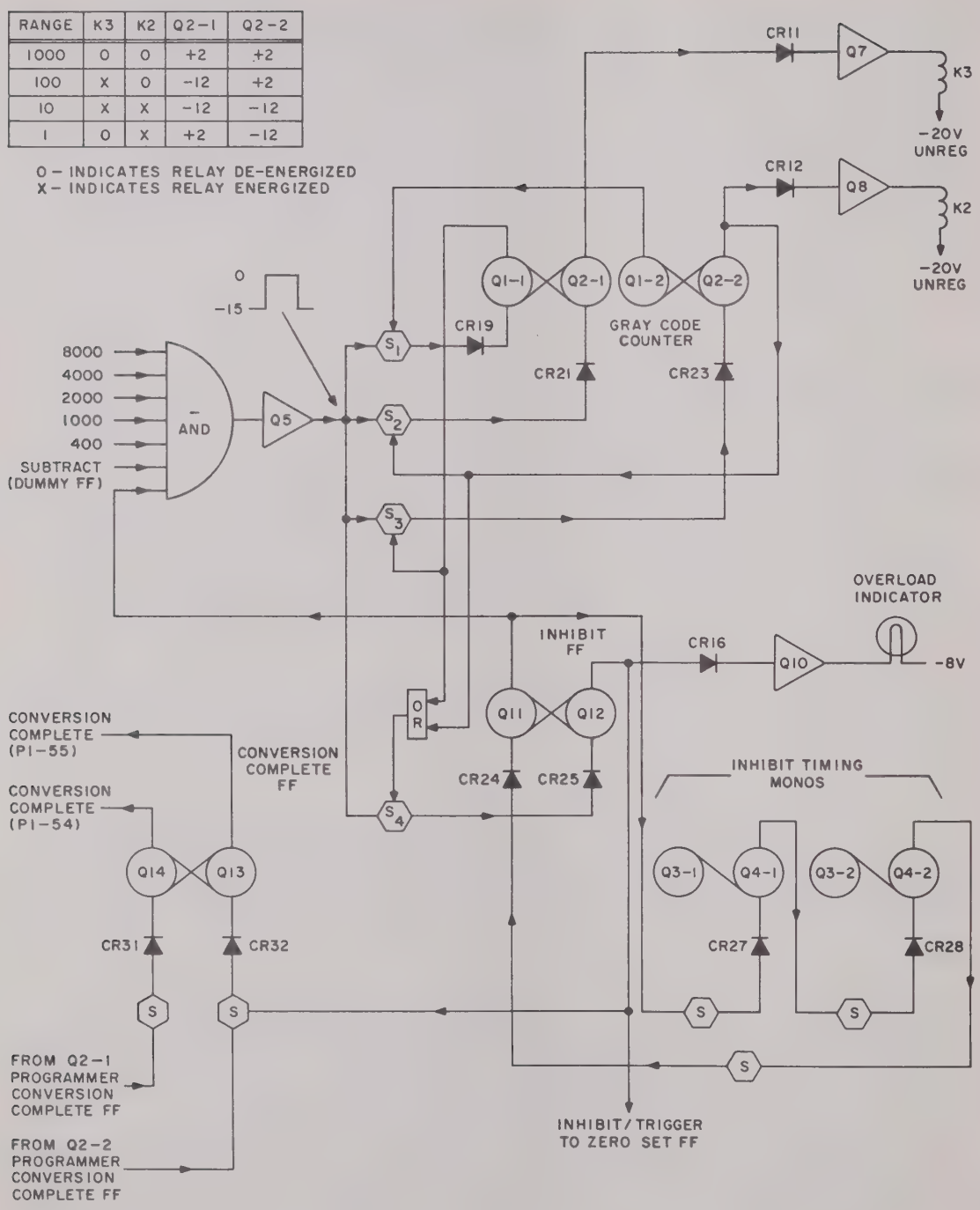


Figure 12. Down Range Logic Diagram

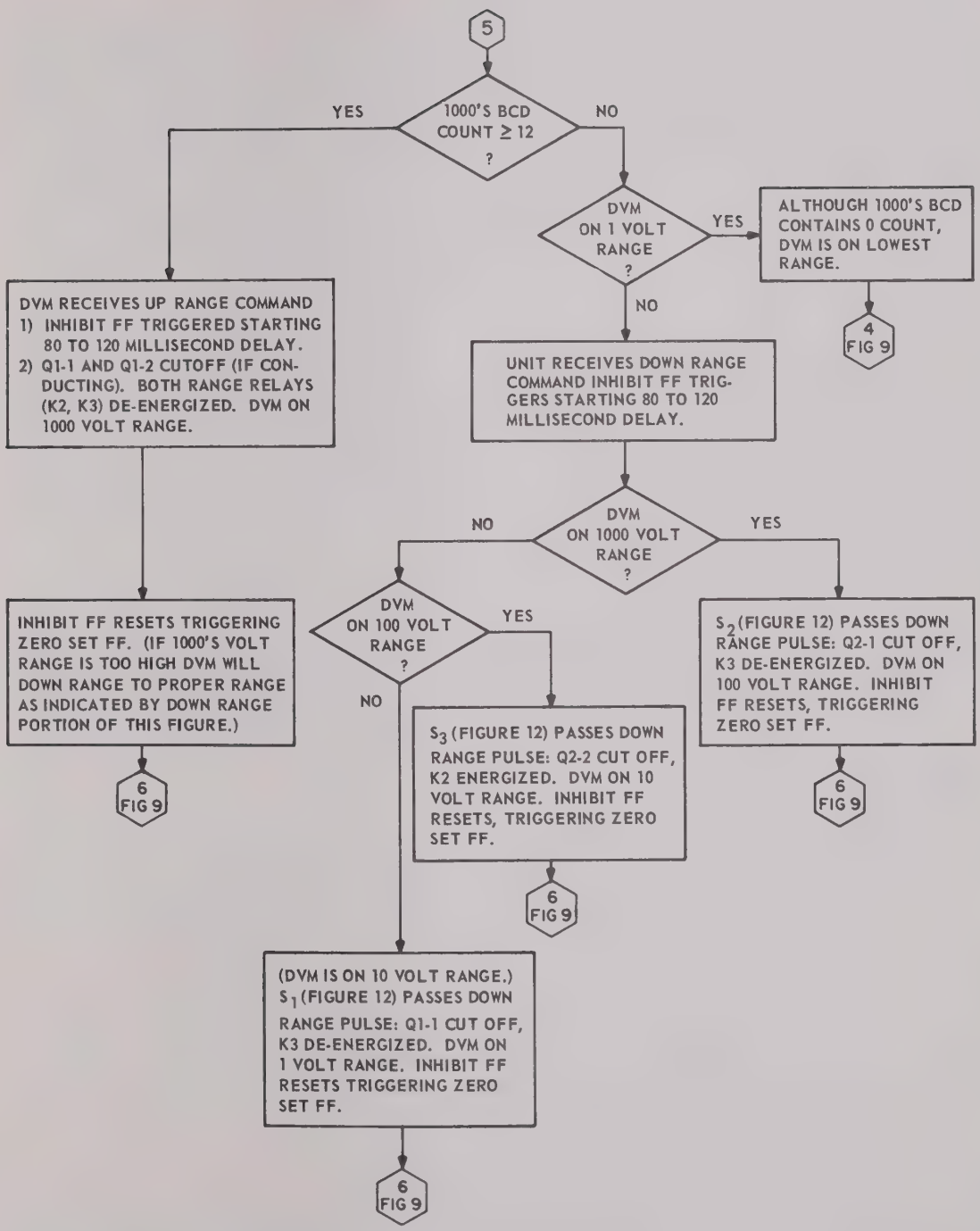

5
1000'S BCD COUNT ≥ 12 ?
YES
NO
DVM ON 1 VOLT RANGE ?
YES
ALTHOUGH 1000'S BCD CONTAINS 0 COUNT, DVM IS ON LOWEST RANGE.
4 FIG 9
NO
DVM RECEIVES UP RANGE COMMAND
1) INHIBIT FF TRIGGERED STARTING 80 TO 120 MILLISECOND DELAY.
2) Q1-1 AND Q1-2 CUTOFF (IF CONDUCTING). BOTH RANGE RELAYS (K2, K3) DE-ENERGIZED. DVM ON 1000 VOLT RANGE.
UNIT RECEIVES DOWN RANGE COMMAND INHIBIT FF TRIGGERS STARTING 80 TO 120 MILLISECOND DELAY.
DVM ON 1000 VOLT RANGE ?
NO
YES
DVM ON 100 VOLT RANGE ?
YES
NO
INHIBIT FF RESETS TRIGGERING ZERO SET FF. (IF 1000'S VOLT RANGE IS TOO HIGH DVM WILL DOWN RANGE TO PROPER RANGE AS INDICATED BY DOWN RANGE PORTION OF THIS FIGURE.)
S2 (FIGURE 12) PASSES DOWN RANGE PULSE: Q2-1 CUT OFF, K3 DE-ENERGIZED. DVM ON 100 VOLT RANGE. INHIBIT FF RESETS, TRIGGERING ZERO SET FF.
S3 (FIGURE 12) PASSES DOWN RANGE PULSE: Q2-2 CUT OFF, K2 ENERGIZED. DVM ON 10 VOLT RANGE. INHIBIT FF RESETS, TRIGGERING ZERO SET FF.
(DVM IS ON 10 VOLT RANGE.) S1 (FIGURE 12) PASSES DOWN RANGE PULSE: Q1-1 CUT OFF, K3 DE-ENERGIZED. DVM ON 1 VOLT RANGE. INHIBIT FF RESETS TRIGGERING ZERO SET FF.
6 FIG 9
6 FIG 9
6 FIG 9
6 FIG 9

Figure 13. DVM Automatic Ranging Logic Flow Diagram

The AND gate of Figure 12 indicates if down ranging is required by sampling the output of the 1000's decade, the 400 flip-flop of the 100's decade and the *subtract* output lead of the Dummy flip-flop. If the 1000, 2000, 4000 and 8000 flip-flop's are all set at zero (outputs at approximately -12 volts) it indicates that the 1000's decade contains a zero count and down ranging may be necessary. This information alone is not sufficient since this condition also exists during the zero set and polarity check portion of the conversion cycle. Therefore, three additional bits of information are required. The subtract level of the Dummy flip-flop indicates that the zero set and polarity check is complete and the digitizing cycle has started; however, for a short period (slightly less than one clock period) all the 1000's flip-flop's are negative and the subtract lead of the Dummy flip-flop is also negative. Thus, the NOT output of the 400's flip-flop is also required. When this output becomes negative it means the 400 flip-flop has triggered and therefore the zero state of the 1000's decade is a legitimate zero count and a down range command is required. The third bit of information required to permit the down range command is a negative level from Q11 of the Inhibit flip-flop on the auto range card. This level indicates if the DVM is already in the process of down ranging and prevents possible triggering of the DVM by a false down range command.

With all of the inputs negative, Q5 produces a positive going pulse which is applied to the four differentiators S_1 through S_4. The differentiators are released or inhibited depending on the range the DVM is on when the command is generated. The following table lists the DVM range, the state of the two Gray Code Counter flip-flop's, and the differentiators that are released when the DVM is in a particular range. (The gray code counters are considered in the ZERO state when their respective right-hand transistors are conducting.)

Range	Q1-1, Q2-1 Flip-Flop	Q1-2, Q2-2 Flip-Flop	Released Differentiator
1000	0	0	S_2 and S_4
100	1	0	S_3 and S_4 (S_2)
10	1	1	S_1 and S_4 (S_3)
1	0	1	(S_1)

Comparing this table with Figure 12 the function of each differentiator may be derived as follows: a pulse through S_1 sets the Q1-1, Q2-1 flip-flop in the 0 state; a pulse through S_2 sets the Q1-1, Q2-1 flip-flop in the ONE state; a pulse through S_3 sets the Q1-2, Q2-2 flip-flop in the ONE state; a pulse through S_4 triggers the Inhibit flip-flop. Thus, a pulse through S_2 sets the DVM

from the 1000 to the 100 volts range; a pulse through S_3 from the 100 to 10 volt range and a pulse through S_1 from the 10 to 1 volt range. Under the released differentiator column of the table (the 100, 10, and 1 volt ranges) are differentiator designations in parentheses; these differentiators although released, do not function in the actual down range operation. They are differentiators to flip-flop's that are in the proper state both for the range the DVM is on prior to, and after, the down ranging cycle; they, therefore, tend to insure their associated flip-flop's are in the correct state when a down range pulse is received.

As indicated, a pulse through S_4 triggers the Inhibit flip-flop Q11 and Q12 (S_4 is inhibited in the 1 volt range since the DVM cannot go lower in range). The quiescent state of the Inhibit flip-flop is Q11 cut off (-12 volt collector), Q12 conducting (+2 volt collector). When triggered the Inhibit flip-flop performs five functions: 1) Q12 inhibits the Zero Set flip-flop of the programmer for the duration of the sign change sequence 2) Q12 also permits Q10 to conduct; this causes the overload lamp to light thus visually indicating to the operator that a sign change is in effect 3) Q12 inhibits the Conversion Complete flip-flop on the auto range card thus maintaining its indication that a conversion cycle is still in process 4) Q11 inhibits both the up and down range and gates preventing possible false ranging commands 5) Q11 triggers the first of the two inhibit timing monostable multivibrators. The two monos provide a 80 to 120 millisecond time delay permitting the range relays (K2 and K3) to change state as dictated by the new count of the gray code counter. (When the first mono resets it triggers the second mono.) When the delay is complete the second mono resets to its quiescent state and in doing so resets the Inhibit flip-flop.

The Inhibit flip-flop in resetting sends a positive going pulse that triggers the Zero Set flip-flop and restarts the conversion cycle from point (6) of Figure 9, Part I. If the DVM is still on too high a range, the down range sequence as described is repeated. *The DVM only down ranges one range at a time.*

NOTE

When operating the DVM with manual range selection the emitter ground of Q5 is removed thus, disabling the down range circuit.

(2) *Up Range Circuit.* Figure 14 is a logic diagram of the up range portion of the 14.201 Automatic Range Switching Circuit (driver Q9, shown dotted, is not in the circuit when the RANGE switch is in the AUTO position as assumed for this description). The necessity of

up ranging is indicated when the 1000's decade records a count of 12 (or more). Thus, if the $\overline{8000}$, $\overline{4000}$, and $\overline{400}$ are all negative it indicates the 1000's decade contains a 12 or larger count; the Dummy flip-flop subtract input indicates a conversion cycle is in progress, and a negative level of Q11 of the Inhibit flip-flop indicates a ranging sequence is not in progress.

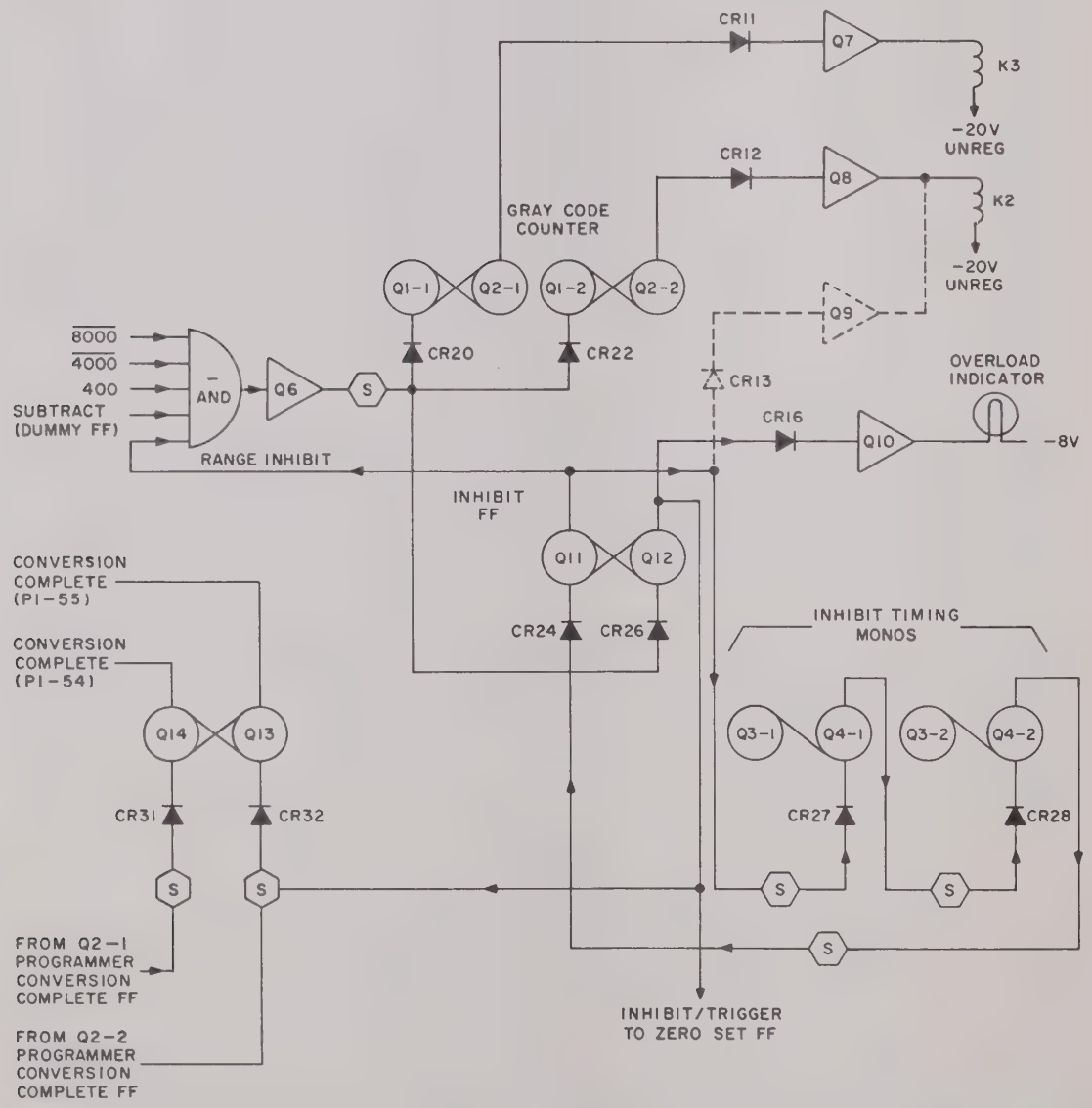


Figure 14. Up Range Logic Diagram

If all five of the conditions are met, Q6 sends a positive going pulse that cuts off Q1-1 and Q1-2 of the gray code counters and also triggers the Inhibit flip-flop. Cutting off Q1-1 and Q1-2 (if either or both are conducting) de-energizes K2 and K3 placing the DVM in the 1000 volt range. The Inhibit flip-flop and the Inhibit Timing monostable multivibrators perform the same functions as described for the down ranging sequence. Note that regardless of what range the DVM is on, an up range command always sets the DVM in the 1000 volt range. If necessary, the DVM then down ranges to the proper range for the input being measured. This characteristic provides the manual range selection overload protection as indicated in the following sub-paragraph.

(3) *Manual Range Overload Protection.* Unlike the down range circuit, the up range circuit of the 14.201 Unit is not disabled in the manual range selection mode of operation. The up range circuit is the same as shown on Figure 14 except that Q8 is disabled and K3 is controlled directly from the RANGE switch. (The Gray Code counter, therefore, has no control over the DVM ranging.)

The function of the overload circuit is primarily to protect the precision 100,000 ohm input resistor of the 1 and 10 volt ranges. The 10 megohm resistor (of the 100 and 1000 volt range) can handle up to 1200 volts continuous overload when the DVM is on the 100 volt range. For this reason the overload circuit only controls relay K2, de-energizing this relay when an overload is applied. The effect of controlling K2 is as follows: 1) If the DVM is on the 100 volt range the instrument remains on this range but the overload lamp lights, 2) if the DVM is on the 10 volt range K2 is de-energized (DVM reverts temporarily to the 100 volt range) and the overload lamp lights, 3) if the DVM is on the 1 volt range K2 is de-energized (DVM temporarily set to the 1000 volt range) and the overload lamp lights. The DVM remains in the temporary range for the 80-120 millisecond duty cycle of the Inhibit flip-flop. As the Inhibit flip-flop resets the DVM reverts to the original manual selected range; however, after approximately 0.8 to 500 milliseconds for INT LOW and 0.8 to 16.7 milliseconds for INT HIGH (60 cps line frequency) trigger modes, the overload protection circuit will switch the DVM back to the temporary higher range. The 16.7 millisecond overload when compared to the 80-120 millisecond period is sufficiently short for protection of the 100,000 ohm resistor. (Note that whenever the INT LOW trigger is used a voltage greater than 120 volts dc on the 1 or 10 volt ranges may damage the precision input resistors.)

If an overload exists, Q6 provides a positive going pulse, via the AND gate, and triggers the Inhibit flip-flop. The Inhibit flip-flop and the associated Inhibit Timing monos provide an 80-120 millisecond delay and light the overload indicator as previously described. In addition the

Inhibit flip-flop cuts off Q9 (if the unit is on the 10 or 1 volt range) and de-energizes K2. As before, when the Inhibit flip-flop resets (and the DVM reverts to the manually selected range) it triggers the Zero Set flip-flop and the conversion cycle is restarted. This procedure continues, with the overload lamp on, until the operator selects a high enough range to properly measure the input signal level.

e. Manual or Single Cycle Command Circuit

The operation of the DVM in the previous descriptions assumed the instrument was continuously triggered at a specific sampling cycle rate: INT LOW, 1-3 cps; INT HIGH, 50 or 60 cps (depending on ac line frequency); or essentially free running (via master clock, P4-65 to P4-50) at 1000 cps. However, by placing the TRIGGER switch (S5) in the MAN position the DVM will cycle only when the MANUAL switch (S7) is depressed. The conversion cycle will be made at the normal DVM rate (approximately one millisecond) but the instrument will then stop and hold this readout until the MANUAL switch is again pushed. The input generated by depressing S7 triggers the Zero Set flip-flop in the same manner as any conversion command signal. The DVM operation through the conversion cycle is the same as previously described.

4. EXTERNAL CONTROL CIRCUITS

Many of the DVM signal functions and control point inputs are terminated on the P1 and P4 connectors at the rear of the instrument. The uses of these terminations are too numerous to attempt to cover in this handbook. The three most common external control circuits are briefly described in the following sub-paragraphs, the reader is referred to Tables 5 and 6 in Chapter 2 for additional information concerning P1 and P4.

a. Remote Range Control

Connector P4 provides facilities for remote range selection of the DVM. When the RANGE switch (S3) is placed in the REMOTE position, ground on the switch wiper is connected to P4-42. By means of contact closure between P4-42 and P4-43 (automatic ranging; 6001 only) or P4-46 (100 volt range) or P4-45 (10 volt range) or P4-44 (1 volt range) the DVM ranging can be controlled remotely. The contact closure should be capable of handling 100 milliamperes of current.

b. External Conversion Command

Placing the TRIGGER switch (S5) in the external position permits external generation of the conversion command pulse. The pulse is applied to the DVM via P4-50. (See Table 6, Chapter 2.)

This input may be used for an external single cycle circuit or for a repetitive input. If desired P4-50 may be connected to P4-65 (the DVM master clock; 20-28 kc frequency). In this case the DVM starts a conversion cycle at about one millisecond intervals (1000 conversion per second). This sample rate if generally used in conjunction with an external hold circuit.

c. External Hold Circuit

If desired to hold the DVM readout for periods longer than normally provided by the frequency of the conversion command signal, an external hold input is provided at P4-66. Applying negative 15 volts to this input provides a fixed readout, within one millisecond, that will be retained until this *hold* voltage is removed.

The readout data for external use is available in both binary-coded decimal (P4) and common decimal (P1) form. (See Tables 5 and 6, Chapter 2.) Thus, the DVM readout capabilities can be used with a multitude of external equipment. The instruments can be used as a fast analog-to-digital converter when triggered by its own master clock (1000 conversions per second).

5. REFERENCE CIRCUITS AND POWER SUPPLIES

a. Reference Voltage Supply

The reference voltage supply consists of the 6.736 Reference Amplifier and a stable voltage source provided by a breakdown diode regulating network. The 6.736 Unit is a chopper-stabilized dc amplifier. (A simplified schematic diagram of the reference supply is shown on Sheet 4 of Drawing D026 203 0S in Appendix II.)

The breakdown diode network (6.210 Oven Network) is connected between the +40 volt line and ground; the unit provides a stable reference level for the amplifier at pin 2 of the oven network. This level is applied to one end of a voltage divider circuit consisting of R28 through R31; the -100 volt output of the amplifier is applied at the other end. The level at the wiper of R29 is used as the input of the amplifier; thus any variations in the -100 volt output are compared to the stable breakdown diode oven level.

The 6.736 Reference Amplifier card also contains the rectifier and regulator circuits for the -110 volt supply. The 1/8 ampere fuse for this supply is also located on the 6.736 Card.

b. Power Distribution

The 6000 and 6001 Series instruments operate directly from a commercial 115/230 volt 50/60 cycle source as indicated in Chapter 2, Paragraph 2.

Sheet 4 of Drawing D026 203 0S and Sheet 3 of Drawing D026 257 0S, (Appendix II) shows the ac input lines, the power transformer (T1), the bridge rectifiers, and associated regulator circuits (in block form) for all the DVM power supplies. In addition, the distribution of the various ac and dc potentials throughout the DVM is shown.

Detailed circuitry for the regulators (not shown in detail on the overall schematics) is shown on Drawing D043 141 0S. The -110 volt regulator and -100 volt reference circuits are shown on Drawing D006 736 0S as indicated in the previous sub-paragraphs.

The power circuits of the DVM supply the following dc voltages: -110, -100, +40, ±20, ±15, +2 and -7.5 volts regulated, -8 and -24 volts unregulated. The power circuits also provide 115 volts ac for the cooling fan (for both 115 and 230 volt inputs), 12 volts ac for the programmer pulse shaper (provides INT HIGH clock frequency), and 6.3 volts ac to the choppers on the 6.736 and 6.463 Amplifiers, and 6.3 vac to the heater in the comparator and breakdown diode oven.

CHAPTER 5

MAINTENANCE

1. GENERAL CONSIDERATIONS

The Models 26.203 and 26.257 DVM's are designed for long-term accuracy and trouble free operation. The use of solid-state components (except for choppers, range and polarity relays) and conservatively rated components, in conjunction with the strong U-shaped metal chassis and high-quality etched-circuit boards ensures long term reliability.

In addition to the material contained in this paragraph, schematic and wiring diagrams of the DVM are bound in Appendix II (including component location diagrams) and a complete list of replaceable parts, including descriptions and part numbers, is bound in Appendix I. (Information on ordering spare or replacement parts from EAI is found immediately after the title page in the front of this handbook.)

It should be noted that these maintenance instructions and data cannot cover all possible troubles and malfunctions; it is, therefore, essential that maintenance personnel become thoroughly familiar with the DVM circuitry. General purpose maintenance data cannot be substituted for technical knowledge of the instrument.

2. TEST POINTS CONNECTOR

As previously indicated a TEST POINTS connector (P2) is mounted on the rear panel to permit monitoring strategic circuits within the DVM. The connector terminations may be used directly or may be cabled to a central monitoring facility.

One suggested method of utilizing the TEST POINTS connector for trouble analysis is to make comparisons between test points of an operational instrument and the malfunctioning unit. In cases where a comparison instrument is not available, all test point levels or waveforms should be recorded when the instrument is first placed into service. Thus, if trouble occurs at a later time the recorded set of normal signals can aid in trouble shooting. (In the case of waveforms careful note of all DVM controls should also be made to insure a valid comparison.)

Table 7 lists all terminations of the TEST POINTS connector, the circuit or source of the voltage at each terminal, and the circuit level or function.

NOTE

Should the -100 volt reference be inadvertently shorted to ground the 1/8 ampere fuse on the 6.736 Reference Amplifier Card (-110 volt circuit) will open.

Table 7. TEST POINTS Connector Terminations

Connector Terminal	Circuit	Voltage or Function
1	Reference Amplifier Balance	For balancing of Reference Amplifier 6.736. See Paragraph 2, Chapter 3.
2	-100 Volts Reference	-100 VDC ±0.005%
3	+40 VDC Power Supply Regulator	+40 VDC ±1%
4	Reference Zener Check	+9.4 VDC ±10%
5	-20 Power Supply Regulator	-20 VDC ±1%
6	-110 Power Supply Regulator	-110 VDC ±1%
7	Conversion Complete Pulse	See Waveshape (e), Figure 8
8	Amplifier B Output	Determined by Input and Range Setting
9	Amplifier A Output	Determined by Input and Range Setting
10	+2 Power Supply (Unreg.)	+2 VDC ±15%
11	+15 Power Supply Regulator	+15 VDC ±5%
12	+20 Power Supply Regulator	+20 VDC ±1%
13	-8 Power Supply Regulator	-8 VDC ±7%
14	-15 Power Supply Regulator	-15 VDC ±5%
15	Zero Set	-12 volt level with one +2 volt pulse (100 microseconds duration) per sampling cycle.
16	±Ground	
17	Amplifier A Balance	For balancing Amplifier A. See Paragraph 2, Chapter 3.
18	Amplifier B Balance	For balancing Amplifier B. See Paragraph 2, Chapter 3.

3. TROUBLE ANALYSIS

To assist in analyzing malfunctions, the DVM circuits should be considered as subdivided into five groups: the input circuits (including both dc amplifiers and associated circuits), the resistor matrix and comparator circuit, the digitizing circuits (including the programmer, and the four BCD counters), the automatic range circuit, and the reference and power circuits. All measurements of signal circuits should be made with a high impedance device, such as an oscilloscope, to prevent circuit loading and possible misleading results.

a. Reference Circuit and Power Supplies

All power and reference supplies terminate at the TEST POINTS connector P2. The levels and tolerances are listed in Table 7 of this Chapter. A rough check of the -100 volt reference supply can be made with a VTVM or scope, however, for an accurate check a test circuit at least ±0.005% accuracy should be used.

b. Input Circuits

The general operating condition of the two input amplifiers can be quickly checked by performing the balancing procedures outlined in Chapter 3, Paragraphs 2*c.* and *d.* Inability to balance usually indicates an amplifier circuit malfunction.

If the DVM functions normally for negative inputs but malfunction with positive inputs, amplifier B is probably faulty. If the DVM only malfunctions on one range the fault is probably in the feedback circuit of amplifier A for that range. If the 1 and 10 volt ranges malfunction but the 100 and 1000 volt ranges function normally, the input resistor (R2, NW-1) for the 1 and 10 volt ranges should be suspected. A vice-versa condition would indicate the input resistor of the 100 and 1000 volt ranges (R1, NW-1).

With a known input the output of amplifier A can be checked at P2-9 (TEST POINTS connector). The amplifier A gain should be 12.5 on the 1 volt range, 1.25 on the 10 volt range, 0.125 on the 100 volt range and 0.0125 on the 1000 volt range. The output of amplifier B (P2-8) should equal that of amplifier A and be opposite in polarity.

c. Resistor Matrix and Comparator Circuit

The resistor matrix is best checked by performing the accuracy check outlined in Paragraph 4 of this chapter.

Malfunction of the comparator is indicated (but not confirmed) if the DVM, with no input, indicates an overload in the manual range selection mode or up ranges to the 1000 volt range in the AUTO range mode. If the DVM registers all zeros with a signal input the comparator is probably at fault.

CAUTION

If the DVM is in AUTO ranging and registers a zero readout with a signal input (over 10 volts) immediately remove the input or switch the DVM to the 100 or 1000 volt range. The all zero readout in the AUTO range mode will cause the DVM to down range to the 1 volt range. The 100K input resistor can be damaged if a large input is maintained on this resistor.

A suspected comparator malfunction can be verified by monitoring pin A8-47 with a scope; compare to curve (a) of Figure 8.

d. Automatic Ranging Circuit (6001 DVM Only)

The automatic ranging circuit can be checked by connecting a variable power supply to the input. Set this source to some value less than 1.0 volt. Place the DVM in the AUTO ranging mode and increase the input to over 1.2 volts. The DVM should up range to the 1000 volt range (note that overload lamp momentarily flickers) then down range to the 100 volt and then 10 volt range. Decrease the input to slightly less then 1 volt and the DVM should down range to the 1 volt range.

The automatic overload circuit can be checked by placing the DVM on the 1 volt range and applying a 1.5 volt input. The overload lamp should flicker on and off while the DVM switches between the 1000 and 1 volt ranges.

e. Digitizing Circuits

The visual readout indicator serves as one of the best trouble indicators for the digitizing circuitry. Accordingly, the trouble-shooting procedures of this sub-paragraph are grouped with respect to possible indicator displays.

NOTE

All four of the BCD counters can be interchanged for trouble shooting purposes. However, to insure maximum lamp life the 1000's counter should be returned to its own position (A4).

(1) *Indicators Displaying Fixed Reading.* A fixed readout display (assuming the input amplifiers and comparator have been eliminated as possible trouble sources) usually indicates that the digitizing cycle has stopped.

If the DVM is being used in conjunction with external equipment that supplies a hold signal check that the external hold voltage is not the cause of the cycle stoppage. This can usually be checked simply by removing connector P4. If the input signal is also applied via this connector the held readout should change to 0000 (unless the cycle command is also received via this connector).

The loss of the master clock pulses (22-28 kc clock) will also stop the digitizing cycle. Check for the clock pulses at P4-65.

If one or more of the lowest order display readouts are at zero, the counting cycle probably has stopped in the lowest order decade that is displaying a digit higher than zero. The suspected decade counter can be checked by interchanging it with the next lower order counter. If the count again stops at the suspected card the fault is isolated. All of the counters are interchangeable including the Model 38.027-1 1000's counter. However, if the 1000's counter is repositioned during trouble analysis it should be returned to the 1000's position. The DVM will function with this card in any position, but, since it normally drives two lamps (thus provides a greater total current via the light drivers) it should be returned to the 1000's position to insure longer lamp life.

If the conversion command signal source is suspected switch the TRIGGER switch to one of the other conversion command sources.

(2) *Indicator Displaying Continually-Changing Random Digits.* This display indicates the digitizing circuits are functioning but trouble may exist in the input circuits. If the unit is used in conjunction with external equipment that supplies a hold voltage it could indicate the failure of the hold signal.

(3) *Two Digits Displayed Simultaneously on a Single Indicator.* This display usually indicates a faulty diode in the BCD to decimal conversion matrix. The faulty diode can be isolated by noting the particular combination of digits.

NOTE

Noise on the input signal may cause one or more of the lowest order displays to flicker between digits.

4. ACCURACY CHECK

Due to the high accuracy of the DVM, a complete calibration procedure is necessarily an exacting process. It is the purpose of this paragraph to provide an accuracy check to determine what, if any, of the calibration adjustments are necessary to bring the instrument within the required specification. It is suggested that all results be double checked before attempting the indicated calibration adjustments. This check assumes the operational checks of Paragraph 2, Chapter 3, have been performed and the instrument is functioning properly.

NOTE

The DVM is factory calibrated to 0.01% of full scale + one digit. To check the DVM accuracy a dc power source with an error of less than or equal to 0.0025% is required. If this high accuracy is not required and a less accurate source is used the allowable error must be 0.01% of full scale +1 digit + the error of the dc voltage source. (Thus for a DVM accuracy requirement of 0.05% of full scale a 0.03% of full scale dc source could be used.)

Allow a one-half hour warm up period of all equipment to assure DVM circuit and test equipment stabilization before starting the check procedure. Place the TRIGGER switch on INT HIGH, the RANGE switch to the 10 volt position and the INPUT IMPEDANCE switch on MAX. Apply the inputs listed in Table 8 and check for the indicated readout (±% additional full scale error due to the power source).

Table 8. Accuracy Check Inputs, First Test

Input Level	DVM Readout	Summing Resistor Gates Checked
-9.999 VDC	-9.997 to -10.001	8 and 1
-7.777 VDC	-7.775 to -7.779	4, 2 and 1
-6.666 VDC	-6.664 to -6.668	4 and 2
-5.555 VDC	-5.553 to -5.557	4 and 1
-3.333 VDC	-3.331 to -3.335	2 and 1

If certain combinations are in error one particular summing resistor gate adjustment may seem to be indicated as faulty. However, this should not be considered as conclusive since two gates may be in error and their errors may cancel when used in combination with each other. If erroneous readouts are obtained apply the inputs listed in Table 9 and check for the indicated readout.

Table 9. Accuracy Check Inputs, Second Test

Input Level*	DVM Readout	Summing Resistor Gates Checked
-8.003	-8.001 to -8.005	8000
-4.003	-4.001 to -4.005	4000
-2.003	-2.001 to -2.005	2000
-1.003	-1.001 to -1.005	1000
-0.803	-0.801 to -0.805	800

If all the gates are in error, with the 8000's gate error largest and the error progressively decreasing (the 400's gate error the smallest), the full scale setting may need adjustment, or, the -100 volt reference may be out of tolerance. Check these adjustments as outlined in Paragraphs 3*a.* and 3*c.* of Chapter 6 (it is best to check reference first since adjustment of the full scale control interacts with the gate adjustments).

If one or more of the gates are in error adjust these gates as outlined in Paragraphs 3*d.* (1) through 3*d.* (5), Chapter 6.

**The last digit of the input (millivolt digit) should be 3 millivolts + the % error of the dc source; this assures that the 1000's 8, 4, 2 and 1 and the 100's 8 gates conduct.*

NOTE

After making any adjustment to the DVM repeat the check-out procedure starting with Table 8.

If both checks are within specifications proceed as follows:

(1) Apply an input of -10.000 volts and note the readout (should be between +9.998 and +10.002).

(2) Apply an input of +10.000 volts. The readout should be between +0.998 and +10.002 volts plus any error between the two voltage sources (if separate positive and negative supplies are used) in addition to the basic full scale error of the power sources.

If the positive readout is in error the gain of amplifier B may require adjustment.

(3) Switch the meter to the 1 volt range and apply -1.000 volt and then +1.000 volt. Again the readout should be between 0.9998 and 1.0002 volt (plus power source errors).

(4) Repeat the procedure on the 100 and 1000 volt ranges using ±100 volts for the 100 volt range and an input greater than or equal to ±500 volts (but less than ±1200 volts) for the 1000 volt range.

If all of the voltages are read out within the tolerances specified the DVM is within the required accuracy specifications and no further check is required nor is calibration needed.

CHAPTER 6

CALIBRATION

1. INTRODUCTION

This chapter contains instructions for a complete calibration of the 6000 or 6001 DVM. It should be noted that calibration of an instrument with the accuracy of the DVM is an exacting procedure requiring precision equipment and extremely stable voltage sources not normally available in field installations (to obtain ±0.01% of full scale +1 digit accuracy). Unless such equipment is available, or a sacrifice of accuracy is permissable, EAI recommends that the DVM be returned to the factory if re-calibration becomes necessary.

Prior to attempting the calibration check, the accuracy check outlined in Chapter 5 should be performed. The check performs a two fold function; it ascertains that calibration is necessary and it localizes the exact calibration adjustment required. This last feature of the check permits the technician to calibrate certain circuits without having to perform the entire calibration procedure.

2. REQUIRED EQUIPMENT

The equipment listed in Table 10 is the type recommended to calibrate the DVM to 0.01% of full scale +1 digit.

3. CALIBRATION PROCEDURES

Allow a one hour warm up period for the DVM and all test equipment to assure circuit stabilization before proceeding. (Place DVM in STANDBY.)

a. Reference Level Adjustment

(1) Balance the reference amplifier. Connect a multimeter (Triplett 630A or equal) between pin 1 and 16 of the TEST POINTS connector P2. Adjust R9 on the 6.736 Reference Amplifier Card for a zero reading on the 3 volt range.

(2) Set up the test circuit illustrated in Figure 15. (The setting of the ratio bridge is determined by the actual potential of the standard cell.)

Table 10. Recommended Test Equipment

Component	Recommended Type	Used For
Precision Ratio Bridge (Accurate to 0.001%)	Julie SCRS 505 Voltage Reference Set (or Equal)	Reference Adjustment
Precision Voltage Divider (6-Place)	Julie VDR 106 (or Equal)	1. DC Gain Adjustment 2. Summing Network Trimmer Adjustment
Galvanometer (Capable of Detecting 1/10 Microvolt or Better)	Hewlett-Packard, Model 425A (or Equal)	1. Reference Adjustment 2. DC Gain Adjustment 3. Summing Network Trimming Adjustment
Microammeter (Capable of Reading 0.004 Microamperes)	Hewlett-Packard, Model 425A (or Equal)	Unloading Adjustment
Secondary Standard Volt Cell (Calibrated at 0.002%)	Epley MIN II Calibrated Against a Primary Standard (or Equal)	Reference Adjustment
Two 30,000 Ohm, Ten-Turn Potentiometers	Helipot, Model 30,000-A1 (or Equal)	Summing Network Trimming Adjustment
Stable DC Source (Stable to +0.005%)		1. DC Gain Adjustment 2. Summing Network Trimming Adjustment

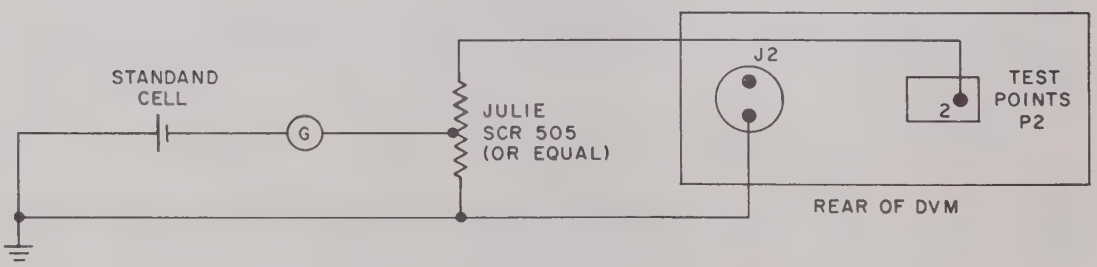


Figure 15. Reference Level Adjustment Test Setup

(3) Adjust R29 and R30 on the 6.736 Unit (Figure 16) until a null is obtained on the galvanometer. (This procedure sets the reference level at -100 vdc ±0.005%.

b. Test Reference Calibration (-10 VDC)

The following procedure provides a -10 vdc ±0.005% test reference source for use in the full scale adjustment, summing resistor trim pot adjustments, and the DVM unloading adjustment. (This source may also be used for dc gain adjustment if desired.)

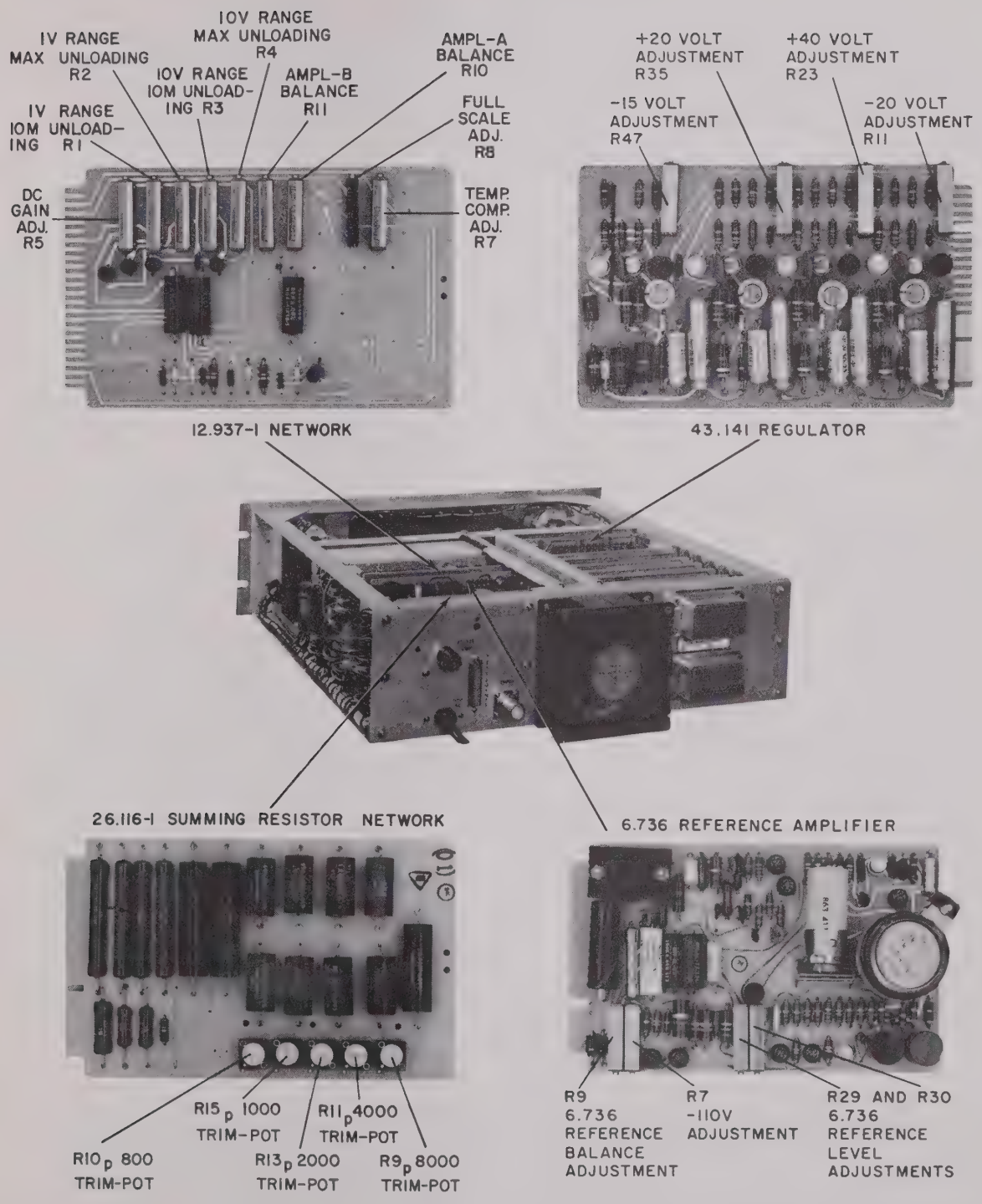


Figure 16. Calibration Controls Location

(1) Set up the test circuit illustrated in Figure 17. (The setting of the ratio bridge is determined by the actual potential of the standard cell.)

(2) Adjust the stable dc source output for a null on the galvanometer. This sets the test reference level at -10 volts ± 0.005%.

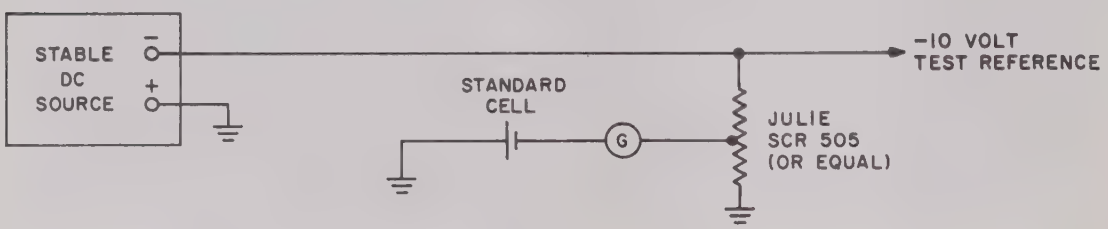


Figure 17. -10 Volt Test Reference Calibration Setup

c. Full Scale Adjustment

The full scale adjustment can *appear* to correct summing resistor gate errors; likewise, adjustment of the summing resistor gates may *appear* to correct a misadjustment of full scale. An indication of full scale misadjustment, therefore, should be verified by the accuracy check procedure outlined in Chapter 5, Paragraph 4. Also for this reason, the initial control position, as indicated in the following procedure, should be recorded. Thus the full scale adjustment can be returned to its original position if the final check of this procedure indicates that the full scale adjustment was not the cause of the error.

NOTE

Before attempting to adjust the full scale adjustment check the -100 volt reference level as outlined in Paragraph a. above.

(1) Check the amplifier balance as outlined in Chapter 3, Paragraph 2*a.*, *b.*, *c.* and *d.*

(2) Place the POWER switch ON (from STANDBY) and the RANGE switch to the 10 volt range.

(3) Set up the test circuit shown in Figure 18. (The -10 volt test reference is obtained as described in Paragraph *b.* above.)

(4) Zero the DVM indicators as outlined in Chapter 3, Paragraph 2*e.*

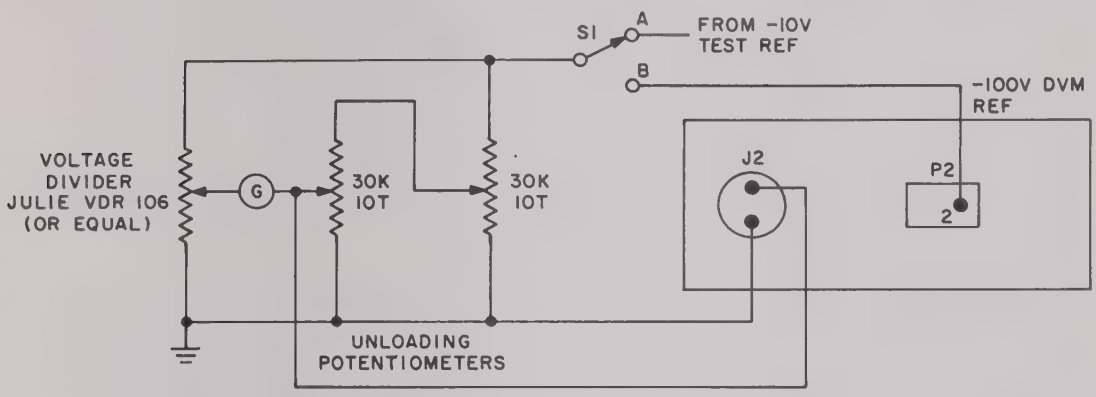


Figure 18. Test Setup for Full Scale and Summing Resistor Time Pot Adjustments

(5) Place the DVM RANGE switch in the 10 volt position.

(6) Place switch S1 of the Figure 18 test circuit in position A.

(7) Set the voltage divider for 9.998 volts; adjust the unloading potentiometers for a galvanometer null. Note and carefully mark the present position of the full scale control (Figure 16, R8 on the 12.937-1 Network).

(8) Adjust the full scale control for a DVM readout of -9.998 volts.

NOTE

The display should remain constant over a wide range of the full scale adjustment potentiometer. Determine this range and set the control at the center.

(9) Place the DVM in the 100 volt range and place switch S1 of the test circuit in position B. (Check galvanometer null.) The meter should readout -99.98 volts.

(10) Once the full scale adjustment has been completed check that the DVM makes a smooth counting transition through each of the trim gates as indicated in the following list:

THIS TABLE IS REVISED
SEE PAGE 2 PINK REVISION SHEET

Apply Input for DVM Readout of	Increase Input for Readout of	Further Increase Input for Readout of
-77.99V	-80.00V	-80.01V
-39.99V	-40.00V	-40.01V
-19.99V	-20.00V	-20.01V
-09.99V	-10.00V	-10.01V
-07.00V	-08.00V	-08.01V
-03.99V	-04.00V	-04.01V

from 80.01

If the unit does not make a smooth counting transition, (for example if the DVM switches -77.99 -79.99 volts to -80.00 volts but jumps to -80.02 as the input is ~~increased~~ decreased thus skipping -80.01) it indicates a summing resistor trim pot is improperly set. Recheck all of the gates as outlined in the accuracy check in Chapter 5. If it is found that all of the gates are out, reset the full scale control to the recorded initial position and repeat the accuracy check to isolate the faulty summing resistor trimming adjustment(s).

d. Summing Resistor Gate Trim Pot Adjustments

Check the DVM Zero adjustment as outlined in Paragraph 2*e.* of Chapter 3. Use the test setup of Figure 18 for the following adjustments. If the accuracy check in Chapter 5 indicates a specific gate is in error it is only necessary to adjust that particular gate. (Calibration of the -100 volt reference should be checked before adjusting any gates.) The DVM should be on the 100 volt range for all of the following adjustment.

(1) *8000 Trim Pot Adjustment (Figure 16)*

(a) Set the test circuit switch S1 (Figure 18) in position B. (Set the DVM in STANDBY and check the Zero adjustment.)

(b) Apply an input of -80.015 volts to the DVM. (Check galvanometer for a null condition.)

(c) Adjust R9p on the 26.116-1 Summing Resistor Network (NW-2) until the readout flickers between -80.01 and -80.02.*

(d) Set the DVM in STANDBY and re-check zero. If zero requires resetting repeat Steps *(a)* through *(d)*.

**Approach all setting from the high side, e.g., 80.03 to 80.02 to flickering condition.*

(e) Vary input to ascertain that the unit counts smoothly from -79.99 to -80.01. If not repeat Steps *(a)* through *(e)*.

(f) If this is the last trim pot adjustment to be made repeat accuracy check of Chapter 5.

(2) *4000 Trim Pot Adjustment (Figure 16)*

(a) Set the test circuit switch S1 (Figure 18) in position B. (Set the DVM in STANDBY and check the Zero adjustment.)

(b) Apply an input of -40.015 volts to the DVM. (Check galvanometer for a null condition.)

(c) Adjust R11p on the 26.116-1 Summing Resistor Network (NW-2) until the read-out flickers between -40.01 and -40.02. *

(d) Set the DVM in STANDBY and re-check zero. If zero requires resetting repeat Steps *(a)* through *(d)*.

(e) Vary input to ascertain that the unit counts smoothly from -39.99 to 40.01. If not repeat Steps *(a)* through *(e)*.

(f) If this is the last trim pot adjustment to be made repeat the accuracy check of Chapter 5.

(3) *2000 Trim Pot Adjustment (Figure 16)*

(a) Set the test circuit switch S1 (Figure 18) in position B. (Set the DVM in STANDBY and check the Zero adjustment.)

(b) Apply an input of -20.015 volts to the DVM. (Check galvanometer for a null condition.)

(c) Adjust R13p on the 26.116-1 Summing Resistor Network (NW-2) until the read-out flickers between -20.01 and -20.02. *

(d) Set the DVM in STANDBY and re-check zero. If zero required resetting repeat Steps *(a)* through *(d)*.

**Approach all settings from the high side.*

(e) Vary input to ascertain that the unit counts smoothly from -19.99 to -20.01. If not repeat Steps *(a)* through *(e)*.

(f) If this is the last trim pot adjustment to be made repeat the accuracy check of Chapter 5.

(4) *1000 Trim Pot Adjustment (Figure 16)*

(a) Set the test circuit switch S1 (Figure 18) in position B. (Set the DVM in STANDBY and check the Zero adjustment.)

(b) Apply an input of -10.015 volts to the DVM. (Check galvanometer for a null condition.)

(c) Adjust R15p on the 26.116-1 Summing Resistor Network (NW-2) until the readout flickers between -10.01 and -10.02.*

(d) Set the DVM in STANDBY and re-check zero. If zero requires resetting repeat Steps *(a)* through *(d)*.

(e) Vary input to ascertain that the unit counts smoothly from -09.99 to -10.01. If not repeat Steps *(a)* through *(e)*.

(f) If this is the last trim pot adjustment to be made repeat the accuracy check of Chapter 5.

(5) *800 Trim Pot Adjustment (Figure 16)*

(a) Set the test circuit switch S1 (Figure 18) in position B. (Set the DVM in STANDBY and check the Zero adjustment.)

(b) Apply an input of -08.015 volts to the DVM. (Check galvanometer for a null condition.)

(c) Adjust R10p on the 26.116-1 Summing Resistor Network (NW-2) until the readout flickers between -08.01 and -08.02.*

(d) Set the DVM in STANDBY and re-check zero. If zero requires resetting repeat Steps *(a)* through *(d)*.

**Approach all settings from the high side.*

(e) Vary input to ascertain that the unit counts smoothly from -07.99 to -08.01. If not repeat Steps *(a)* through *(e)*.

(f) Repeat the accuracy check of Chapter 5.

e. DC Gain Adjustment (Figure 16)

(1) Set up the test circuit shown in Figure 19, and apply an input of -10.00 volts.

(2) Set the DVM on the 10 volt range.

(3) Adjust the voltage divider for a DVM readout -10.000 then -10.001 and back to -10.000. Note the divider control range; set the control at the center of this range and record the DVM readout.

(4) Reverse the dc source plus and minus leads thus applying a positive input to the DVM (if separate plus and minus dc sources are used they should be equal in magnitude within ±0.005%).

(5) If the readout magnitude noted in Step *(f)* is not equal to that of Step (3) adjust R5 on the 12.937-1 Network (NW-3). Re-check Steps (3) and (4).

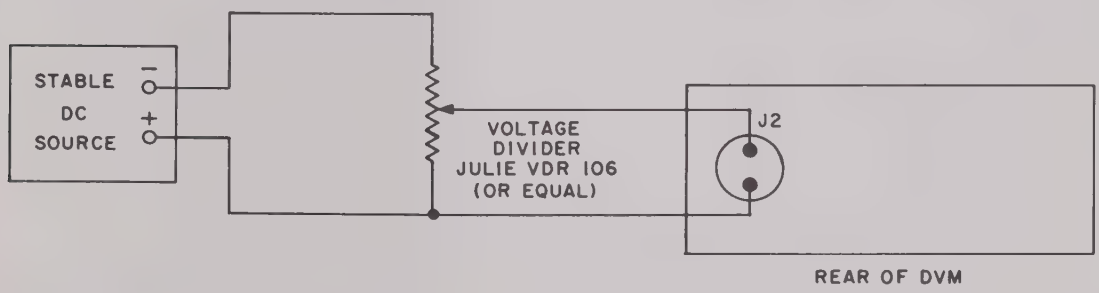


Figure 19. DC Gain Adjustment Test Setup

f. Unloading Adjustment 10 Volt Range (Figure 16)

Two methods are given for setting the unloading adjustment of the DVM. The first method is the more exacting procedure, however, this procedure requires a more elaborate test set up which includes precision test equipment. The second method is by far the simpler of the two methods; in this case, however, the accuracy of the procedure depends primarily on the precise value of the *known* resistor.

First Method:

(1) Set up the test circuit shown in Figure 20a. Place test circuit switch S1 in position B.

(2) Set up the voltage divider for a 10.000 volt input to the DVM; null the galvanometer.

(3) Set the DVM RANGE switch in the 10 volt position and the INPUT IMPEDANCE switch in the MAX position.

(4) Place test circuit switch S1 in position A.

(5) Adjust R4 on the 12.937-1 Network (NW-3) until the DVM is drawing minimum current from source voltage (maximum allowable reading 0.02 microampere). This provides the DVM with an input impedance $\geq$ 500 megohms at full scale on the 10 volt range.

(6) Switch the INPUT IMPEDANCE to the 10M position.

(7) Maintaining the 10 volt input adjust R3 on the 12.937-1 Network (NW-3) until the DVM is drawing exactly 1 microampere of current from the source voltage. This provides the DVM with a 10 megohm input impedance in the 10M position of the INPUT IMPEDANCE switch.

Second Method:

(1) Set up the test circuit shown in Figure 20b.

(2) Place the DVM RANGE switch in the 10V position, the DVM INPUT IMPEDANCE switch in the MAX position and switch S1 of the test circuit in position B.

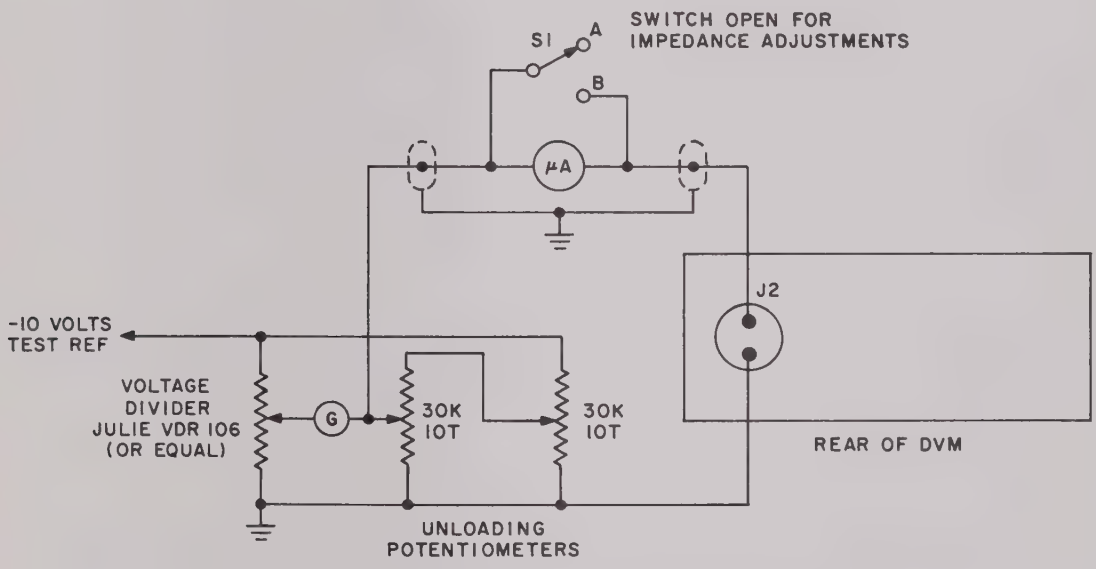
(3) Multiply the value of the test circuit known resistor by 0.02×10^{-6}. This is the maximum allowable voltage drop across the known resistor when the DVM input impedance is 500 megohms at full scale on the 10 volt range.

(4) Place the test circuit switch in position A and note the difference of the readout from switch position B. If the difference is greater than calculated in Step (3) above, adjust R4 on the 12.937-1 Network (NW-3) until this difference is equal to or less than the calculated amount. This provides the DVM with an input impedance of approximately 500 megohms at full scale on the 10 volt range (depending on the accuracy of the known resistor).

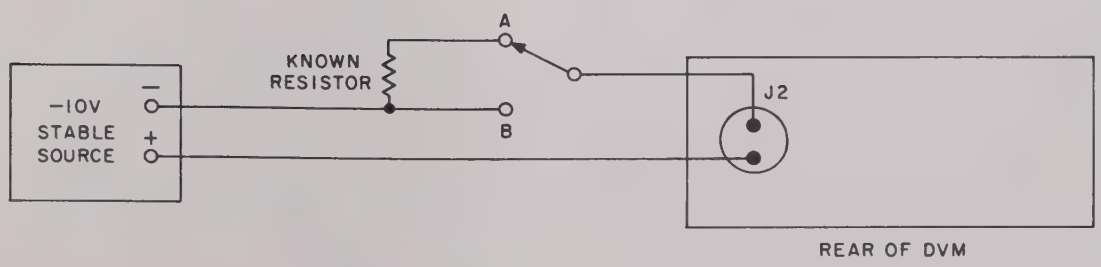
(5) Multiply the known resistor value by 1×10^{-6}. This is the allowable voltage drop across the known resistor when the DVM input impedance is 10 megohms on the 10 volt range.

(6) Place the DVM INPUT IMPEDANCE switch in the 10M position.

(7) Place the test circuit switch in position B, then in position A and note the difference in readout. If the difference is not the same as calculated in Step (5) adjust R3 on the 12.937-1 Network (NW-3) until it is the same. This provides the DVM with a 10 megohm input impedance on the 10 volt range when the INPUT IMPEDANCE switch in in the 10M position.



a. TEST CIRCUIT FIRST METHOD



b. TEST CIRCUIT, ALTERNATE METHOD

Figure 20. DVM Unloading Adjustment Test Setups.

g. Unloading Adjustment 1 Volt Range (Figure 16)

Again, as in the 10 volt range unloading procedure, two methods are given for the unloading adjustment of the 1 volt range. The first method is the more exacting but the second method is the simpler of the two to perform.

First Method:

(1) Set up the test circuit shown in Figure 20a. Place test circuit switch S1 in position B.

(2) Set up the voltage divider for a 1.0000 volt input to the DVM; null the galvanometer.

(3) Set the DVM RANGE switch in the 1 volt position and the INPUT IMPEDANCE in the MAX position.

(4) Place the test circuit switch S1 in position A.

(5) Adjust R2 on the 12.937-1 Network (NW-3) until the DVM is drawing minimum current from the voltage source (maximum allowable reading 0.004 microamperes). This provides the DVM with an input impedance at full scale of $\geq$250 megohms on the 1 volt range.

(6) Switch the INPUT IMPEDANCE switch to the 10M position.

(7) Maintaining the 1 volt input adjust R1 on the 12.937-1 Network until the DVM is drawing exactly 0.1 microampere of current from the voltage source. This provides the DVM with a 10 megohm input impedance in the 10M position of the INPUT IMPEDANCE switch.

Second Method:

(1) Set up the test circuit shown in Figure 20b but replace the 10 volt source with a stable 1 volt source.

(2) Place the DVM RANGE switch in the 1V position, the DVM INPUT IMPEDANCE switch in the MAX position and switch S1 of the test circuit in position B.

(3) Multiply the value of the test circuit known resistor by 0.004×10^{-6}. This is the maximum allowable voltage drop across the known resistor when the DVM input impedance is 250 megohms at full scale on the 1 volt range.

(4) Place the test circuit switch in position A and note the difference of the readout from switch position B. If the difference is greater than calculated in Step (3) above, adjust R2 on the 12.937-1 Network (NW-3) until this difference is equal to or less than the calculated amount. This provides the DVM with an input impedance of approximately 250 megohms at full scale on the 1 volt range (depending on the accuracy of the known resistor).

(5) Multiply the known resistor value by 0.1×10^{-6}. This is the allowable voltage drop across the known resistor when the DVM input impedance is 10 megohms on the 1 volt range.

(6) Place the DVM INPUT IMPEDANCE switch in the 10M position.

(7) Place the test circuit switch in position B, then in position A and note the difference in readout. If the difference is not the same as calculated in Step (5) adjust R1 on the 12.937-1 Network (NW-3) until it is the same. This provides the DVM with a 10 megohm input impedance on the 1 volt range when the INPUT IMPEDANCE switch is in the 10M position.

APPENDIX I

REPLACEABLE PARTS LISTS

6000 AND 6001 SERIES DIGITAL VOLTMETERS
MODELS 26.257 AND 26.203

This appendix contains a Replaceable Parts List for the equipment described in this manual. In each case, a brief description of the part is listed. Where applicable, a reference symbol (schematic designation) is included. To enable a particular sheet to be readily located, an index precedes the individual replaceable parts lists.

The category column in the parts list indicates the availability of each listed part so that a replacement part can be obtained as quickly as possible. The components in category A are standard electronic items that are usually available from any commercial electronic supplier. In order to expedite obtaining items of this nature, it is suggested that they be purchased from a local source whenever possible. If necessary these parts may be ordered from EAI.

The parts in category B are components that are available only from EAI. When ordering items of this type, please specify the type number and serial number of the basic unit in which the part is located, as well as the part identification.

PLEASE NOTE THAT EAI RESERVES THE RIGHT TO MAKE PART SUBSTITUTIONS WHEN REQUIRED. IN ALL CASES EAI GUARANTEES THAT THESE SUBSTITUTIONS ARE ELECTRICALLY AND PHYSICALLY COMPATIBLE WITH THE ORIGINAL COMPONENT.

PARTS LIST INDEX

6000 AND 6001 SERIES DIGITAL VOLTMETERS

MODELS 26.257 AND 26.203

	Model Number	Component	Page
1.	26.203	Series 6001 TDVM	AI-3
	26.257	Series 6000 TDVM	AI-5
2.	6.463-1	Dual DC Amplifier	AI-7
3.	6.736	Reference Amplifier	AI-10
	a. 6.210	Zener Oven	AI-13
4.	12.937-1	Miscellaneous Network	AI-14
5.	12.1036	Relay Network	AI-16
6.	12.1106	Rectifier Network	AI-17
7.	14.201-1	Auto Range Switch Circuit (Series 6001 Only) ...	AI-18
8.	26.116-1	Summing Resistor Network	AI-20
9.	26.242	Comparator and Diode Gate	AI-22
	a. 26.240	Comparator Amplifier	AI-22
	b. 26.244	Diode Gate	AI-22
10.	38.027	BCD-Decimal Decoding Matrix/Counter	AI-23
11.	38.027-1	BCD-Decimal Decoding Matrix/Counter	AI-24
12.	43.141	Regulated Power Supply	AI-25
13.	44.271	Programmer	AI-27

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	B1	Fan, Muffin Venturi: 110V 60 CPS, 13 Watts	B242 022 1	B
2	C1,2,3	Capacitor, Fixed, Electrolytic: 2000 UF -10 +250%, 50V	516 239 0	B
3	C4	Capacitor, Fixed, Electrolytic: 200-200 UF -10 +100%, 250V	516 139 0	B
4	C5	Capacitor, Fixed, Electrolytic: 4000 UF, 15V	516 044 0	B
5	C6,7	Capacitor, Fixed, Electrolytic: 2500 UF -10 +250%, 25V	516 253 0	B
6	C9	Capacitor, Fixed, Paper: 0.5 UF ±10%, 600V	520 074 0	A
7	C10	Capacitor, Fixed, Ceramic: 2700 PF, GMV, 100V	515 007 0	A
8	CR1,2	Diode, Silicon	614 034 0	B
9	CR4	Bridge Rectifier	614 207 0	B
10	DS1	Digital Display Indicator	B554 036 0	B
11	DS2-5	Digital Display Indicator: 12 Terminals	B554 034 0	B
12	F1	Fuse, Cartridge: Slow Blow: 1 1/4 Amp, 125V Bussman Manufacturing Corp. MDL 1 1/4	570 032 0	A
13	K1	Relay, Reed: 60V Max, 2750 ohm	618 222 0	B
14	Q1-7	Transistor, Germanium: PNP	686 066 0	B
15	R1	Resistor, Variable, Wirewound: 200 ohms ±30%, 1/3W	642 641 0	B
16	R2	Resistor, Fixed, Wirewound: 20 ohms ±5%, 10W	C636 421 0	A
17	R3	Resistor, Fixed, Wirewound: 40 ohms ±5%, 10W	C636 445 2	A
18	R4,5	Resistor, Fixed, Wirewound: 10 ohms ±5%, 10W	C636 445 1	A
19	R6	Resistor, Fixed, Wirewound: 3 ohms ±5%, 10W	C636 445 0	A
20	R7,8	Resistor, Fixed, Composition: 6.8 megohms ±10%, 1W	627 685 1	A
21	R9	Resistor, Fixed, Composition: 470 ohms ±10%, 1/2W	626 471 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

DATE 6 / 18 / 64

UNIT TITLE
SERIES 6001 TDVM

MODEL NO.
26.203 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
22	R10	Resistor, Fixed, Film: 56K ohms ±1%, 1/2W	634 010 0	A
23	R11	Resistor, Fixed, Composition: 3.3K ohm ±10%, 1/2W	626 332 1	A
24	R12	Resistor, Fixed, Composition: 3.9 megohms ±10%, 1/2W	626 395 1	A
25	S3,8	Switch, Rotary: Single Pole, 6 Position	C658 194 0	B
26	S4	Switch, Rotary: 3 Position	C658 235 0	B
27	S5,7	Switch, Rotary and Push Button: Single Pole 4 Position	C658 236 0	B
28	T1	Transformer Power: Step-Down and Step-Up	B684 210 0	B
29		Transistor Socket: TO-3 Type	A650 118 0	A

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DATE 6 / 18 / 64

UNIT TITLE

SERIES 6001 TDVM

MODEL NO.

26.203 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	B1	Fan, Muffin Venturi: 110V 60 CPS, 13 Watts	B242 022 1	B
2	C1,2,3	Capacitor, Fixed, Electrolytic: 2000 UF -10 +250%, 50V	516 239 0	B
3	C4	Capacitor, Fixed, Electrolytic: 200-200 UF -10 +100%, 250V	516 139 0	B
4	C5	Capacitor, Fixed, Electrolytic: 4000 UF, 15V	516 044 0	B
5	C6,7	Capacitor, Fixed, Electrolytic: 2500 UF -10 +250%, 25V	516 253 0	B
6	C9	Capacitor, Fixed, Paper: 0.5 UF ±10%, 600V	520 074 0	A
7	C10	Capacitor, Fixed, Ceramic: 2700 PF, GMV, 100V	515 007 0	A
8	CR1,2,3	Diode, Silicon	614 117 0	B
9	CR4	Bridge Rectifier	614 207 0	B
10	DS1	Digital Display Indicator	B554 036 0	B
11	DS2-5	Digital Display Indicator: 12 Terminals	B554 034 0	B
12	F1	Fuse, Cartridge, Slow Blow: 1 1/4 Amp, 125V; Bussman Manufacturing Corp. MDL 1 1/4	570 032 0	A
13	K1	Relay Reed: 60V Max, 2750 ohm	618 222 0	B
14	Q1-7	Transistor, Germanium: PNP	686 066 0	B
15	R1	Resistor, Variable, Wirewound: 200 ohms ±30%, 1/3W	642 641 0	B
16	R2	Resistor, Fixed, Wirewound: 20 ohms ±5%, 10W	C636 421 0	A
17	R3	Resistor, Fixed, Wirewound: 40 ohms ±5%, 10W	C636 445 2	A
18	R4,5	Resistor, Fixed, Wirewound: 10 ohms ±5%, 10W	C636 445 1	A
19	R6	Resistor, Fixed, Wirewound: 3 ohms ±5%, 10W	C636 445 0	A
20	R7,8	Resistor, Fixed, Composition: 6.8 megohms ±10%, 1W	627 685 1	A
21	R9	Resistor, Fixed, Composition: 470 ohms ±10%, 1/2W	626 471 1	A

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DATE 6 / 18 / 64

UNIT TITLE
SERIES 6000 TDVM

MODEL NO.
26.257 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
22	R10	Resistor, Fixed, Film: 56K ohms ±1%, 1/2W	634 010 0	A
23	R11	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
24	R12	Resistor, Fixed, Composition: 3.9 megohms ±10%, 1/2W	626 295 1	A
25	S3,8	Switch, Rotary: 2 Sections, 3 Poles	C658 246 0	B
26	S4	Switch, Rotary: 3 Posistions	C658 235 0	B
27	S5,7	Switch,Rotary and Pushbutton: Single Pole, 4 Position	C658 236 0	B
28	T1	Transformer, Power: Step-Down and Step-Up	B684 210 0	B
29		Transistor Socket: TO-3 Type	A650 118 0	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
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DATE 6 / 18 / 64

UNIT TITLE

SERIES 6000 TDVM

MODEL NO.

26.257 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,10	Capacitor, Fixed, Plastic: .47 UF, 50V	B521 133 0	B
2	C2,9,11,18	Capacitor, Fixed, Electrolytic: 1250 UF ±100% -10%	A516 184 0	A
3	C3,12	Capacitor, Fixed, Ceramic: 100 PF ±10%, 1000V	515 019 0	A
4	C4,13	Capacitor, Fixed, Ceramic: .015 UF ±20%,500V	515 140 0	A
5	C5,14	Capacitor, Fixed, Ceramic: 47 PF ±10%, 1000V	515 017 0	A
6	C6,15,19,20	Capacitor, Fixed, Ceramic: 1000PF ±20%, 75V	515 075 0	A
7	C7,16	Capacitor, Fixed, Electrolytic: .22 UF, 50V	B521 134 0	B
8	C8,17	Capacitor, Fixed, Electrolytic: 4.7 UF ±10%, 35V	516 246 0	A
9	C21,22	Capacitor, Fixed, Ceramic: 8 PF ±10%, 1000V	515 087 0	A
10	C23,24	Capacitor, Fixed, Ceramic: .05 UF +100% -20%, 30V	515 183 0	A
11	CR1-4,9,10	Diode, Silicon	B614 007 0	B
12	CR5-8	Diode, Germanium	614 043 0	B
13	D1	Chopper: 6.3V 60 CPS Coil, DPDT BBM Contacts	530 042 0	B
14	DSI-4	Lamp, Incandescent: 14V, 0.08 Amp. 2317 Type	A578 047 0	A
15	Q1,2,9,10	Transistor, Germanium: PNP	B868 028 0	B
16	Q3,4,11,12	Transistor, Germanium: PNP; 2N652	686 084 0	A
17	Q5,13	Transistor, Silicon: NPN	C686 112 0	B
18	Q6,7,14, 15	Transistor, Germanium: PNP	B686 096 0	B
19	Q8,16	Transistor, Germanium: PNP	686 185 0	B
20	Q17,18,19, 21	Transistor, Germanium: NPN	686 141 0	B
21	Q20,22	Transistor, Germanium: NPN; 2N1308	686 101 0	A
22	R1,27	Resistor, Fixed, Composition: 3.3 megohms ±10%, 1/2W	626 335 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
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DATE 6 / 18 / 64

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.463-1 Sh.1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
23	R2,28	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
24	R3,35	Resistor, Fixed, Composition: 1.8K ohms ±10%, 1/2W	626 182 1	A
25	R4,36	Resistor, Fixed, Composition: 2.2K ohms ±10%, 1/2W	626 222 1	A
26	R5,29	Resistor, Fixed, Composition: 1.6K ohms ±5%, 1/2W	626 162 0	A
27	R6,37	Resistor, Fixed, Composition: 8.2K ohms ±5%, 1/2W	626 822 0	A
28	R7,30	Resistor, Fixed, Composition: 100 ohms ±10%, 1/2W	626 101 1	A
29	R8,31	Resistor, Fixed, Composition: 3.3K ohms ±5%, 1/2W	626 332 0	A
30	R10,33	Resistor, Fixed, Composition: 150K ohms ±10%, 1/4W	625 154 1	A
31	R11,15,25, 26,34,39, 51,52,53,54	Resistor, Fixed, Composition: 100K ohms ±10%, 1/2W	626 104 1	A
32	R12,40	Resistor, Fixed, Composition: 33K ohms ±10%, 1/2W	626 333 1	A
33	R13,41	Resistor, Fixed, Composition: 5.6K ohms ±5%, 1/2W	626 562 0	A
34	R14,38	Resistor, Fixed, Composition: 560K ohms ±10%, 1/2W	626 564 1	A
35	R16,17,46, 48	Resistor, Fixed, Composition: 22K ohms ±10%, 1/4W	625 223 1	A
36	R18,50	Resistor, Fixed, Composition: 3.9K ohms ±10%, 1/4W	625 392 1	A
37	R21,22,42, 43	Resistor, Fixed, Composition: 47K ohms ±10%, 1/2W	626 473 1	A
38	R23,45	Resistor, Fixed, Composition: 270K ohms ±10%, 1/2W	626 274 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
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B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

DATE 6 / 18 / 64

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.463-1 Sh.2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
39	R57,58	Resistor, Fixed, Composition: 150 ohms ±10%, 1/2W	626 151 1	A
40	R59,60	Resistor, Fixed, Composition: 56K ohms ±10%, 1/2W	626 563 1	A
41	R61,62	Resistor, Fixed, Composition: 47 Megohms ±10%, 1/2W	626 476 1	A

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UNIT TITLE
DUAL DC AMPLIFIER

DATE 6 / 18 / 64

MODEL NO.
6.463-1 Sh. 3 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Electrolytic: 20 UF, 150V	516 177 0	A
2	C2	Capacitor, Fixed, Electrolytic: 55 UF -15 +20%, 15V	516 188 0	B
3	C3,5	Capacitor, Fixed, Ceramic: 100 PF ±10%, 1000V	515 019 0	A
4	C4,7,9	Capacitor, Fixed, Ceramic: 0.01 UF +60 -40%, 150V	515 151 0	A
5	C6	Capacitor, Fixed, Ceramic: 22 PF, GMV, 1000V	515 006 0	A
6	C8,13	Capacitor, Fixed, Ceramic: 1000 PF, GMV, 600V	515 005 0	A
7	C10	Capacitor, Fixed, Plastic: 1 UF ±10%, 200V	521 056 0	A
8	C11	Capacitor, Fixed, Electrolytic: 5 UF -15 -20% 50V	516 186 0	A
9	C12,15	Capacitor, Fixed, Electrolytic: 1250 UF, 3V	516 184 0	A
10	C14	Capacitor, Fixed, Electrolytic: 5 UF, 25V	516 182 0	A
11	CR1,2	Diode, Silicon	614 137 0	B
12	CR3	Diode, Silicon: Zener; 12V ±10%, @20 MA.	614 091 0	B
13	CR4,5	Diode, Silicon	B614 007 0	B
14	CR6	Diode, Germanium	614 043 0	B
15	CR7	Diode, Silicon: Zener; 47V ±10%, @5.5 MA.	614 138 0	B
16	D1	Chopper: 6.3V Coil, 60 CPS, SPDT	530 003 0	B
17	F1	Fuse, Cartridge, Fast Acting Type: 1/8 Amp. 250V	570 149 0	B
18	Q1,2,5,6	Transistor, Silicon: PNP; 2N321	686 004 0	A
19	Q3,8,9	Transistor, Silicon: PNP	B686 032 0	B
20	Q4,10	Transistor, Germanium: PNP; 2N652	686 084 0	A
21	Q7	Transistor, Germanium: PNP	686 066 0	B
22	R1	Resistor, Fixed, Composition: 220 ohms ±10%, 2W	628 221 1	A

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DATE 4 / 17 / 64

UNIT TITLE

REFERENCE AMPLIFIER

MODEL NO.

6.736 Sh. 1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
23	R2,35	Resistor, Rixed, Composition: 22K ohms ±10%, 1/2W	626 223 1	A
24	R3,17,33	Resistor, Fixed, Composition: 2.7K ohms ±10%, 1/2W	626 272 1	A
25	R4	Resistor, Fixed, Composition: 27K ohms ±10%, 1W	627 273 1	A
26	R5,8	Resistor, Fixed, Composition: 15K ohms ±10%, 1W	627 153 1	A
27	R6	Resistor, Fixed, Composition: 1.2K ohms ±10%, 1/2W	626 122 1	A
28	R7	Resistor, Variable, Wirewound: 2000 ohms ±10%, 1/4W	642 357 0	B
29	R9	Resistor, Variable, Wirewound: 10,000 ohms ±10%, 1/4W	642 359 0	B
30	R10	Resistor, Fixed, Composition: 1K ohms ±10%, 1/2W	626 102 1	A
31	R11,26,39, 43	Resistor, Fixed, Composition: 68K ohms ±10%, 1/2W	626 683 1	A
32	R12	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
33	R13,46,47,	Resistor, Fixed, Composition: 4.7K ohms ±10%, 1/2W	626 472 1	A
34	R14	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W	626 123 1	A
35	R15	Resistor, Fixed, Composition: 1.8K ohms ±5%, 1/2W	626 182 0	A
36	R16	Resistor, Fixed, Composition: 6.8K ohms ±10%, 1/2W	626 682 1	A
37	R18	Resistor, Fixed, Film: 15,000 ohms ±1%, 1/2W	634 295 0	A
38	R19	Resistor, Fixed, Composition: 1.8K ohms ±10%, 1/2W	626 182 1	A
39	R20	Resistor, Fixed, Composition: 1.2K ohms ±10%, 1W	627 122 1	A

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DATE 6/ 18/ 64

UNIT TITLE

REFERENCE AMPLIFIER

MODEL NO.

6.736 Sh.2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
40	R21	Resistor, Fixed, Film: 3,300 ohms ±1%, 1/2W	634 293 0	A
41	R22	Resistor, Fixed, Composition: 51 ohms ±5%,1W	627 510 0	A
42	R23	Resistor, Fixed, Film: 8,200 ohms ±1%, 1/2W	634 294 0	A
43	R24,41	Resistor, Fixed, Film: 22,000 ohms ±1%, 1/2W	634 296 0	A
44	R25	Resistor, Fixed, Composition: 33K ohms ±10%, 1/2W	626 333 1	A
45	R27	Resistor, Fixed, Composition: 100 ohms ±10%, 1/2W	626 101 1	A
46	R28	Resistor, Fixed, Wirewound, Precision: 100,000 ohms ±.05%, 1/2W	B638 316 0	B
47	R29	Resistor, Variable, Wirewound: 200 ohms ±10%, 1/4W	B642 354 0	B
48	R30	Resistor, Variable, Wirewound: 20 ohms ±10%, 1W	642 324 0	B
49	R31	Resistor, Fixed, Wirewound, Precision: 8.964.14 ohms ±.05%, 1/2W	638 043 0	B
50	R32,45	Resistor, Fixed, Composition: 2.2K ohms ±10%, 1/2W	626 222 1	A
51	R34	Resistor, Fixed, Composition: 33 ohms ±10%, 1/2W	626 330 1	A
52	R36,40	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W	626 103 1	A
53	R37,42	Resistor, Fixed, Composition: 220 ohms ±10%, 1/2W	626 221 1	A
54	R38	Resistor, Fixed, Composition: 120K ohms ±10%, 1/2W	626 124 1	A
55	R44	Resistor, Fixed, Composition: 15K ohms ±10%, 1/2W	626 153 1	A
56	R48	Resistor, Fixed, Film: 700 ohms ±1%, 1/2W	634 339 0	A

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DATE 6/ 18/ 64

UNIT TITLE
REFERENCE AMPLIFIER

MODEL NO.
6.736 Sh.3 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1	Diode, Silicon: Zener; 20V ±5%, @12.5 Ma.	614 088 0	B
2	CR2	Diode, Silicon: Zener; 8.9-9.7V @10 Ma.	614 089 0	B
3	R1	Resistor, Fixed, Film: 880 ohms ±1%, 1/2W	634 342 0	A
4	R1P	Resistor, Padder: Value to be Determined at Time of Manufacture	Order by Description	B

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UNIT TITLE
ZENER OVEN

MODEL NO.
6.210

DATE 4 / 17 / 64

Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C3	Capacitor, Fixed, Ceramic: 330 PF ±10%, 600V	515 073 0	A
2	CR1,4	Diode, Silicon: Zener	B614 118 0	B
3	CR2,3,6,8	Diode, Germanium	614 043 0	B
4	CR10	Diode, Silicon: Zener; 13V ±5%, @48 Ma.	614 131 0	B
5	R1	Resistor, Variable, Wirewound: 500 ohms ±10%, 1/4W	642 316 0	B
6	R1P	Resistor, Padder: Value to be Determined at Time of Manufacture	Order by Description	B
7	R2,3	Resistor, Variable, Wirewound: 100 ohms ±10%, 1/4W	642 314 0	B
8	R2P,3P	Resistor, Padder: Value to be Determined at Time of Manufacture	Order by Description	B
9	R4	Resistor, Variable, Wirewound: 50 ohms ±10%, 1/4W	642 313 0	B
10	R4P	Resistor, Padder: Value to be Determined at Time of Manufacture	Order by Description	B
11	R5	Resistor, Variable, Wirewound: 20 ohms ±10%, 1/4W	642 312 0	B
12	R7	Resistor, Variable, Wirewound: 20,000 ohms ±10%, 1/4W	642 321 0	B
13	R8	Resistor, Variable, Wirewound: 10 ohms ±10%, 2W	642 534 0	B
14	R8P	Resistor, Padder: Value to be Determined at Time of Manufacture	Order by Description	B
15	R10,11	Resistor, Variable, Wirewound: 10,000 ohms ±10%, 1/4W	642 320 0	B
16	R16	Resistor, Fixed, Wirewound, Precision: 50,000 ohms ±0.05%, 1/2W	638 046 0	B
17	R17	Resistor, Fixed, Wirewound, Precision: 5000 ohms ±0.05%	B638 768 0	B
18	R21,22	Resistor, Fixed, Wirewound, Precision: Matched Pair 10,000 ohms @ ±0.05%	A640 043 0	B

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DATE 6 / 18 / 64

UNIT TITLE
MISCELLANEOUS NETWORK

MODEL NO.
12.937-1 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
19	R23,24	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W	626 123 1	A
20	RT1	Thermistor: 10,000 ohms ±10% @25°C	B646 031 0	A

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DATE 6 / 18 / 64

UNIT TITLE
MISCELLANEOUS NETWORK

MODEL NO.
12.937-1 Sh.2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Ceramic: 1000 PF, GMV, 600V	515 005 0	A
2	C2	Capacitor, Fixed, Ceramic: 4700 PF ±20%, 1000V	515 008 0	A
3	CR1-3	Diode, Silicon	614 034 0	B
4	K2,3	Relay Armature: 24 VDC 550 ohm Coil	618 223 0	B
5	NW1	Input Resistor Network	12.879	B
6	R1	Resistor, Fixed, Composition: 56 ohms ±10%, 1/2W	626 560 1	A

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UNIT TITLE
RELAY NETWORK

DATE 6/ 18/ 64

MODEL NO.
12.1036 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1-3	Diode, Silicon	614 117 0	B
2	CR4-8	Diode, Bridge Rectifier	614 224 0	B
3	R1	Resistor, Fixed, Wirewound: 2.7 ohms ±5%, 3W	636 475 0	A
4	R2	Resistor, Fixed, Composition: 47 ohms ±10%, 1W	627 101 1	A

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DATE 6 / 18 / 64

UNIT TITLE
RECTIFIER NETWORK

MODEL NO.
12.1106 Sh.1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1-1,1-2 2-1,2-2,3-1 3-3,21,26, 27	Capacitor, Fixed, Ceramic: 220 PF ±10%, 600V	515 020 0	A
2	C4-1,4-2	Capacitor, Fixed, Electrolytic: 3.3 UF ±10%, 35V	516 276 0	A
3	C11	Capacitor, Fixed, Ceramic: 100 PF ±10%, 1000V	515 019 0	A
4	C12,14-20, 25,28	Capacitor, Fixed, Ceramic: 560 PF ±10%, 150V	515 167 0	A
5	C13	Capacitor, Fixed, Ceramic: 0.01 UF +60% -40% 150V	515 151 0	A
6	C22	Capacitor, Fixed, Ceramic: 3000 PF, GMV, 1000V	515 209 0	A
7	C23,24	Capacitor, Fixed, Electrolytic: 6.8 UF ±10%, 35V	516 277 0	A
8	CR1-28,31, 32,34-37	Diode, Germanium	614 043 0	B
9	Q1-1,1-2 2-1,2-2, 3-1,3-2, 4-1,4-2, 5,6,11,12, 13,14	Transistor, Germanium: PNP; 2N1305	686 077 0	A
10	Q7,8,9,10	Transistor, Germanium: PNP;	686 022 0	A
11	R1-1,1-2 R2-1,2-2 R7-1,7-2 R8-1,8-2 31,41,50, 55	Resistor, Fixed, Composition: 2.2K ohms ±10%, 1/2W	626 222 1	A
12	R3-1,3-2 R4-1,4-2 R9-1,9-2 R10-1,10-2 44,49,56	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W	626 103 1	A

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UNIT TITLE
AUTO RANGE SWITCH CIRCUIT

DATE 6/18/64

MODEL NO.
14.201-1 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
13	R5-1,5-2 R6-1,6-2 R11-1,11-2, R45,46,51, 54	Resistor, Fixed, Composition: 68K ohms ±10%, 1/2W	626 683 1	A
14	R21	Resistor, Fixed, Composition: 27K ohms ±10%, 1/2W	626 273 1	A
15	R22,24,28-30	Resistor, Fixed, Composition: 4.7K ohms ±10%, 1/2W	626 472 1	A
16	R23	Resistor, Fixed, Composition: 15K ohms ±10%, 1/2W	626 153 1	A
17	R25	Resistor, Fixed, Composition: 8.2K ohms ±10%, 1/2W	626 822 1	A
18	R26	Resistor, Fixed, Composition: 56K ohms ±10%, 1/2W	626 563 1	A
19	R27,33-40, 43,52,53	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W	626 123 1	A
20	R32	Resistor, Fixed, Wirewound: 4.7 ohms ±10%, 1W	636 118 0	A
21	R42	Resistor, Fixed, Wirewound: 3.3K ohms ±10%, 1/2W	626 332 1	A

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DATE 6/ 18 / 64

UNIT TITLE

AUTO RANGE SWITCH CIRCUIT

MODEL NO.

14.201-1 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	R1	Resistor, Fixed, Wirewound, Precision: 1,249,685 ohms ±.1%	A638 460 0	B
2	R2	Resistor, Fixed, Film: 12.5 Megohms ±1%, 2W;	634 225 0	A
3	R3	Resistor, Fixed, Film: 2.5 Megohms ±1%, 1/2W	634 187 0	A
4	R4	Resistor, Fixed, Film: 25 Megohms ±1%, 2W	634 189 0	A
5	R5	Resistor, Fixed, Film: 5 Megohms ±1%, 1/2W	634 034 0	A
6	R6	Resistor, Fixed, Film: 50 Megohms ±1%, 2W	634 190 0	A
7	R7	Resistor, Fixed, Film: 10 Megohms ±1%, 1W	634 053 0	A
8	R8	Resistor, Fixed, Film: 100 Megohms ±2%, 2W	634 191 0	A
9	R9	Resistor, Fixed, Wirewound, Precision: 12,442 ohms ±.05%	A638 452 0	B
10	R9p	Resistor, Variable, Wirewound: 50 ohms ±5%, 1W	B642 435 0	B
11	R10	Resistor, Fixed, Wirewound, Precision: 124,586 ohms ±.05%	A638 456 0	B
12	R10p,15p	Resistor, Variable, Wirewound: 500 ohms ±5%, 1W	B642 438 0	B
13	R11	Resistor, Fixed, Wirewound, Precision: 24,896 ohms ±.05%	B638 453 0	B
14	R11p	Resistor, Variable, Wirewound: 100 ohms ±5%, 1W	B642 436 0	B
15	R12	Resistor, Fixed, Wirewound, Precision: 249,749 ohms ±.05%	A638 457 0	B
16	R13	Resistor, Fixed, Wirewound, Precision: 49,811 ohms ±.05%	A638 454 0	B
17	R13p	Resistor, Variable, Wirewound: 200 ohms ±5% 1W	A642 437 0	B
18	R14	Resistor, Fixed, Wirewound, Precision: 499,648 ohms ±.05%	A638 458 0	B
19	R15	Resistor, Fixed, Wirewound, Precision: 99,609 ohms ±.05%	A638 455 0	B

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DATE 4 / 17 / 64

UNIT TITLE
SUMMING RESISTOR NETWORK

MODEL NO.
26.116-1 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
20	R16	Resistor, Fixed, Wirewound, Precision: 999,598 ohms ±.05%	A638 459 0	B
21	R17,18	Resistor, Fixed, Wirewound, Precision (Matched Pair): Total Series Resistance to be 12,533 ohms ±.05%	A640 056 0	B
22	R19	Resistor, Fixed, Composition: 12 Megohms ±10%, 1/2W	626 126 1	A

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DATE 8 / 21 / 64

UNIT TITLE

SUMMING RESISTOR NETWORK

MODEL NO.

26.017 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	HR1,2	Heatpad	646 022 0	B
2	S1	Thermostat Switch	B662 018 0	B
		Comparator Amplifier 26.240		
1	CR1,2	Diode, Germanium	614 043 0	B
2	Q1-6	Transistor, Germanium: PNP; 2N1309	686 102 0	A
3	R1,2	Resistor, Fixed, Composition: 1.8K ohms ±10%, 1/4W	625 182 1	A
4	R3	Resistor, Fixed, Composition: 2.7K ±10%, 1/4W	625 272 1	A
5	R4	Resistor, Fixed, Composition: 12K ohms ±10%, 1/4W	625 123 1	A
6	R5	Resistor, Fixed, Composition: 15K ohms ±10%, 1/4W	625 153 1	A
7	R6,7	Resistor, Fixed, Composition: 5.6K ohms ±10%, 1/4W	625 562 0	A
8	R8	Resistor, Fixed, Composition: 560 ohms ±10%, 1/4W	625 561 1	A
9	R9	Resistor, Fixed, Composition: 750 ohms ±5%, 1/4W	625 751 0	A
10	R10,11	Resistor, Fixed, Composition: 10K ohms ±10%, 1/4W	625 103 1	A
11	R12	Resistor, Fixed, Composition: 330 ohms ±10%, 1/4W	625 331 1	A
12	R13	Resistor, Fixed, Composition: 27K ohms ±10%, 1/4W	625 273 1	A
13	R14,15	Resistor, Fixed, Composition: 100K ohms ±10%, 1/4W	625 104 1	A
		Diode Gate 26.244		
1	CR1-32	Diode, Silicon	C614 199 0	B

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DATE 6 / 18 / 64

UNIT TITLE
COMPARATOR AND DIODE GATE

MODEL NO.
26.242 Sh.1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Ceramic: 1000 PF, GMV, 600V	515 005 0	A
2	CR1-82	Diode, Germanium	614 043 0	B
3	NW1	Circuit Module: Flip-Flop Network	B592 001 0	B
4	NW2	Cicruit Module: Trigger Network	B592 002 0	B
5	NW3	Circuit Module: Differentiating Network	B592 003 0	B
6	Q1-4	Transistor, Germanium: PNP; 2N1305	686 077 0	B
7	Q5-18	Transistor, Germanium: PNP; 2N321	686 004 0	B
8	R1,3,24,25	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
9	R2,4	Resistor, Fixed, Composition: 22K ohms ±10%, 1/2W	626 223 1	A
10	R5-17	Resistor, Fixed, Composition: 1.5K ohms ±10%, 1/2W	626 152 1	A
11	R18	Resistor, Fixed, Composition: 100 ohms ±10%, 1/2W	626 101 1	A
12	R19	Resistor, Fixed, Composition: 1.2K ohms ±10%, 1/2W	626 122 1	A
13	R20	Resistor, Fixed, Wirewound: 4.7 ohms ±10%, 1/2W	636 172 0	A
14	R21	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W	626 103 1	A
15	R22,23	Resistor, Fixed, Composition: 18K ohms ±10%, 1/2W	626 183 1	A

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DATE 6 / 18 / 64

UNIT TITLE
BCD-DECIMAL DECODING MATRIX/COUNTER

MODEL NO.
38.027 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Ceramic: 100 PF, GMV 600V	515 005 0	A
2	CR1-82	Diode, Germanium	614 043 0	B
3	NW1	Circuit Module: Flip-Flop Network	B592 001 0	B
4	NW2	Circuit Module: Trigger Network	B592 002 0	B
5	NW3	Circuit Moduel: Differentiating Network	B592 003 0	B
6	Q1-4	Transistor, Germanium: PNP; 2N1305	686 077 0	B
7	Q5-18	Transistor, Germanium: PNP; 2N321	686 004 0	B
8	R1,3,24,25	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
9	R2,4	Resistor, Fixed, Composition: 22K ohms ±10%, 1/2W	626 223 1	A
10	R5-17	Resistor, Fixed, Composition: 1.5K ohms ±10%, 1/2W	626 152 1	A
11	R18	Resistor, Fixed, Composition: 100 ohms ±10%, 1/2W	626 101 1	A
12	R19	Resistor, Fixed, Composition: 1.2K ohms ±10%, 1/2W	626 122 1	A
13	R20	Resistor, Fixed, Wirewound: 2.7 ohms ±5%, 1/2W	636 432 0	A
14	R21	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W	626 103 1	A
15	R22,23	Resistor, Fixed, Composition: 18K ohms ±10%, 1/2W	626 183 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

DATE 6 / 18 / 64

UNIT TITLE
BCD-DECIMAL DECODING MATRIX/COUNTER

MODEL NO.
38.027-1 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,5,9,13	Capacitor, Fixed, Electrolytic: 100 UF, 25V	516 145 0	A
2	C2,6,10,14	Capacitor, Fixed, Ceramic: 0.01 UF ±20%, 500V	515 139 0	A
3	C3,7,11,15	Capacitor, Fixed, Electrolytic: 5 UF, 25V	516 182 0	A
4	C4,8,12,16	Capacitor, Fixed, Electrolytic: 50 UF, 25V	516 149 0	A
5	CR1,4,6,8	Diode, Germanium	614 043 0	B
6	CR2,5,7	Diode, Silicon: Zener; 15V ±3%, @ 5MA	614 104 0	B
7	CR3	Diode, Silicon: Zener; 15V ±5%	614 215 0	B
8	CR9	Diode, Silicon: Zener; 13V ±5%, @ 48MA	614 131 0	B
9	CR11	Diode, Silicon: Zener; 7.3 to 7.9V @ 90MA, 1.5W	614 169 0	B
10	Q1,4,7,10	Transistor, Germanium: PNP; 2N1039	686 045 0	A
11	Q2,5,8,11	Transistor, Germanium: PNP; 2N652	686 084 0	A
12	Q3,6,9,12	Transistor, Germanium: NPN; 2N377	686 017 0	A
13	R1,13,25	Resistor, Fixed, Composition: 330 ohms ±10%, 1W	627 331 1	A
14	R2,14,26, 38	Resistor, Fixed, Composition: 100 ohms ±10%, 1W	627 101 1	A
15	R3,15,27	Resistor, Fixed, Composition: 390 ohms ±5%, 1W	627 391 0	A
16	R4,16,28	Resistor, Fixed, Composition: 1.2K ohms ±10%, 1/2W	626 122 1	A
17	R5,17,29, 41	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
18	R6,18,30, 42	Resistor, Fixed, Composition: 330 ohms ±10%, 1/2W	626 331 1	A
19	R7,19,31, 43	Resistor, Fixed, Composition: 1K ohm ±10%, 1/2W	626 102 1	A
20	R8,21,32, 44	Resistor, Fixed, Composition: 5.6K ohms ±10%, 1/2W	626 562 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

DATE 6 / 29 /64

UNIT TITLE

REGULATED POWER SUPPLY

MODEL NO.

43.141 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
21	R9,20,33, 45	Resistor, Fixed, Composition: 560 ohms ±10%, 1/2W	626 561 1	A
22	R10,22,34, 46	Resistor, Fixed, Composition: 150 ohms ±5%, 1/2W	626 151 0	A
23	R11,23,35, 47	Resistor, Variable, Wirewound: 500 ohms ±10%	B642 355 0	B
24	R12,24,36, 48	Resistor, Fixed, Composition: 1K ohms ±5%, 1/2W	626 102 0	A
25	R37	Resistor, Fixed, Composition: 180 ohms ±10%, 1/2W	626 181 1	A
26	R39	Resistor, Fixed, Composition: 200 ohms ±5%, 2W	628 201 0	A
27	R40	Resistor, Fixed, Composition: 820 ohms ±10%, 1/2W	626 821 1	A
28	R50	Resistor, Fixed, Composition: 120 ohms ±5%, 2W	628 121 0	A
29	R51	Resistor, Fixed, Composition: 120 ohms ±10%, 1W	627 121 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

UNIT TITLE
REGULATED POWER SUPPLY

DATE 6 / 29 / 64

MODEL NO.
43.141 Sh.2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,2,4,6,8-12,20	Capacitor, Fixed, Ceramic: 560 PF ±10%, 600V	515 146 0	A
2	C3,7	Capacitor, Fixed, Ceramic: 1800 PF ±10%, 150V	515 215 0	A
3	C5,19,21,24	Capacitor, Fixed, Ceramic: 0.01 UF ±20%, 1000V	515 009 0	A
4	C13	Capacitor, Fixed, Electrolytic: 4.7 UF ±10%, 35V	516 246 0	A
5	C14,15	Capacitor, Fixed, Ceramic: 1000 PF, GMV, 600V	515 005 0	A
6	C16	Capacitor, Fixed, Ceramic: 220 PF ±10%, 600V	515 020 0	A
7	C17	Capacitor, Fixed, Electrolytic: 1.5 UF ±20%, 35V	516 310 0	A
8	C22	Capacitor, Fixed, Ceramic: 5600 PF ±20%, 1500V	515 186 0	A
9	C23	Capacitor, Fixed, Electrolytic: 22 UF ±20%, 25V	516 331 0	A
10	CR1-27, 29-32	Diode, Germanium	614 043 0	B
11	CR28,33	Diode, Silicon	B614 007 0	B
12	Q1-1-Q5-2, Q6,8,9	Transistor, Germanium: PNP; 2N1305	686 077 0	A
13	Q10,11,14	Transistor, Germanium: PNP; 2N1309	686 102 0	A
14	Q12,13	Transistor, Germanium: PNP; 2N2160	686 172 0	A
15	R1	Resistor, Fixed, Composition: 18K ohms ±10%, 1/2W	626 183 1	A
16	R2-5,8,9, 11,12,17, 18,20,32	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W	626 123 1	A
17	R6,7,24, 25,28	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W	626 103 1	A
18	R10	Resistor, Fixed, Composition: 39K ohms ±10%, 1/2W	626 393 1	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

UNIT TITLE
PROGRAMMER

DATE 6 / 18 / 64

MODEL NO.
~~44~~.271 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
19	R13,38	Resistor, Fixed, Composition: 1K ohm ±10%, 1/2W	626 102 1	A
20	R15	Resistor, Fixed, Composition: 3.9K ohms ±10%, 1/2W	626 392 1	A
21	R16,19,21	Resistor, Fixed, Composition: 47K ohms ±10%, 1/2W	626 473 1	A
22	R26,30	Resistor, Fixed, Composition: 2.2K ohms ±10%, 1/2W	626 222 1	A
23	R27	Resistor, Fixed, Composition: 10K ohms ±5%, 1/2W	626 103 0	A
24	R29,40	Resistor, Fixed, Composition: 68K ohms ±10%, 1/2W	626 683 1	A
25	R31	Resistor, Fixed, Composition: 5.6K ohms ±10%, 1/2W	626 562 1	A
26	R35,43	Resistor, Fixed, Composition: 3.3K ohms ±10%, 1/2W	626 332 1	A
27	R36,42	Resistor, Fixed, Composition: 82K ohms ±10%, 1/2W	626 823 1	A
28	R39	Resistor, Fixed, Composition: 22K ohms ±10%, 1/2W	626 223 1	A
29	R41	Resistor, Fixed, Composition: 2.7K ohms ±10%, 1/2W	626 272 1	A
30	R44	Resistor, Fixed, Composition: 43K ohms ±5%, 1/2W	626 433 0	A
31		Circuit Module: Flip-Flop Network	B592 001 0	B

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.

UNIT TITLE
PROGRAMMER

DATE 6/ 18 / 64

MODEL NO.
44.271 Sh. 2 of 2 Sh.

APPENDIX II

DRAWINGS

6000 AND 6001 SERIES DIGITAL VOLTMETERS
MODELS 26.257 AND 26.203

This appendix contains necessary schematics and wiring diagrams of equipment described in this manual. To facilitate locating a particular sheet, an index is provided that lists the model number of each unit or component, the type of drawings, and the associated drawing number. The drawings are bound into the manual in the order listed under the index Drawing Number column.

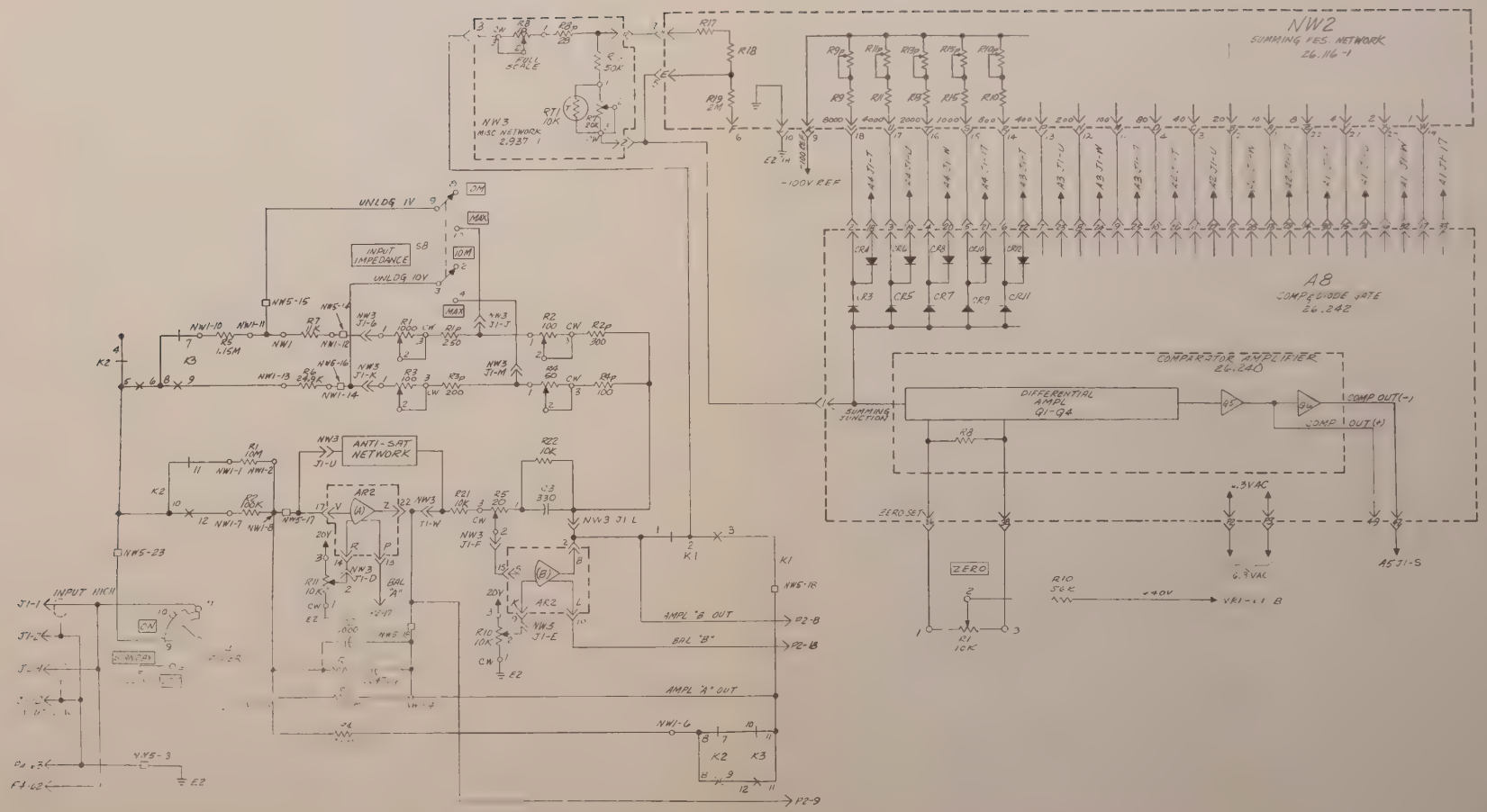
EAI drawings are prepared in accordance with standard drafting practices for electro-mechanical and electronic equipment. All symbols are in accordance with current government standards.

INDEX

Unit or Component	Type of Drawing	Drawing Number
6001 Series DVM	Schematic Wiring	D026 203 0S (4 Sheets) D026 203 0W (5 Sheets)
6000 Series DVM	Schematic Wiring	D026 257 0S (3 Sheets) D026 257 0W (5 Sheets)
6.464-1 Dual DC Amplifier	Schematic	D006 463 0S
6.663 Buffer Inverter	Schematic	A006 663 0S
6.736 Reference Amplifier	Schematic	D006 736 0S
12.937 Network Card	Schematic	C012 937 0S
12.1036 Relay Network	Schematic Wiring	C012 1036 0S C012 1036 0W
12.1106 Rectifier Network	Schematic	B012 1106 0S
14.201 Auto Range Card (6001 Only)	Schematic	D014 201 0S
26.116 Summing Resistor Network	Schematic	C026 116 0S
26.242 Comparator Amplifier and Diode Gate 26.240 Comparator Amplifier	Schematic Wiring Schematic	C026 242 0S B026 242 0W B026 240 0S

DRAWINGS (Cont)

Unit or Component	Type of Drawing	Drawing Number
38.027 BCD Counter and Decoding Matrix	Schematic	D038 027 0S
43.141 Power Supply Regulator	Schematic	D043 141 0S
44.271 Programmer	Schematic	D044 271 0S



ELECTRONIC ASSOCIATES, INC.	
LONG BRANCH, NEW JERSEY	
SCHEMATIC	
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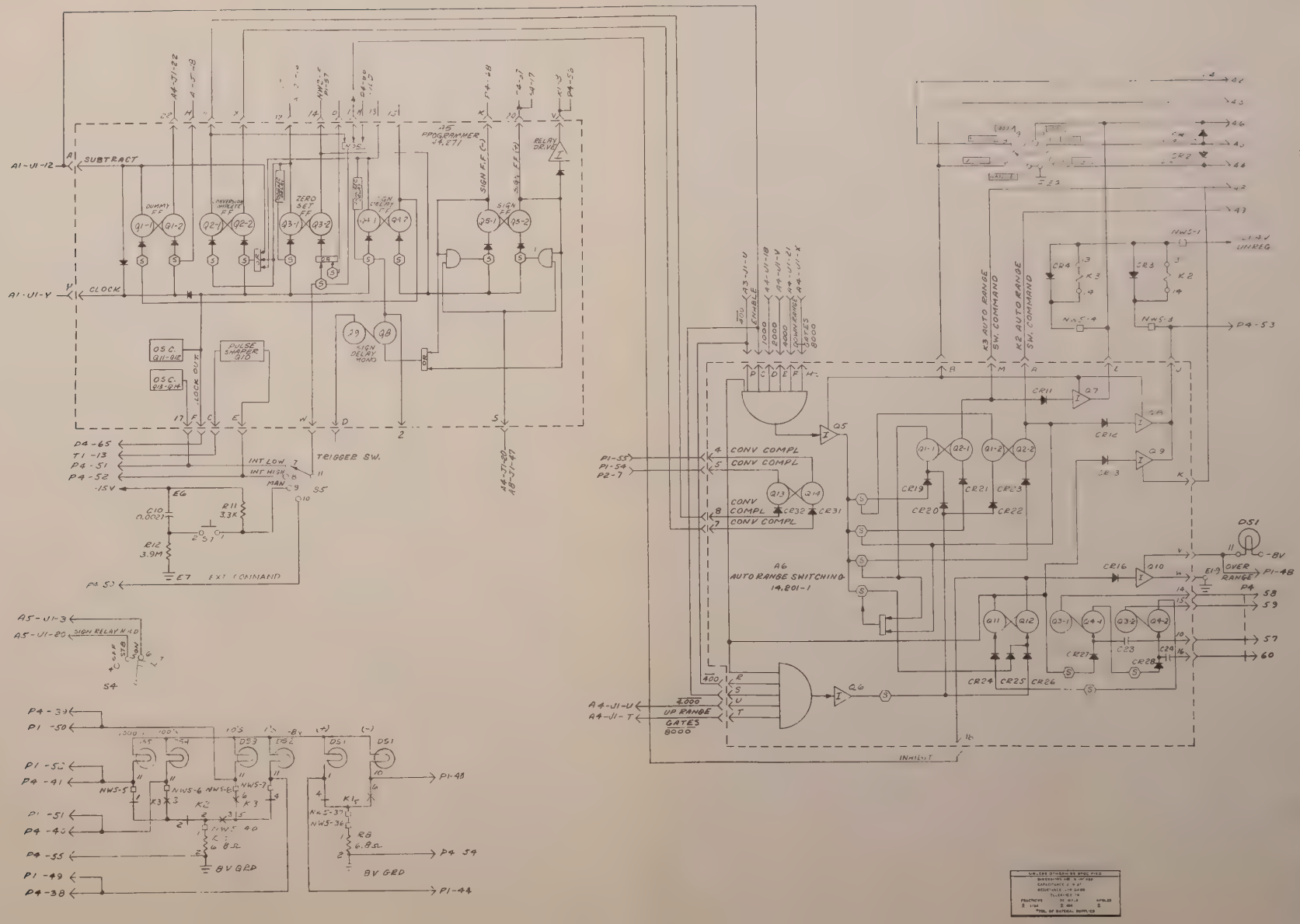
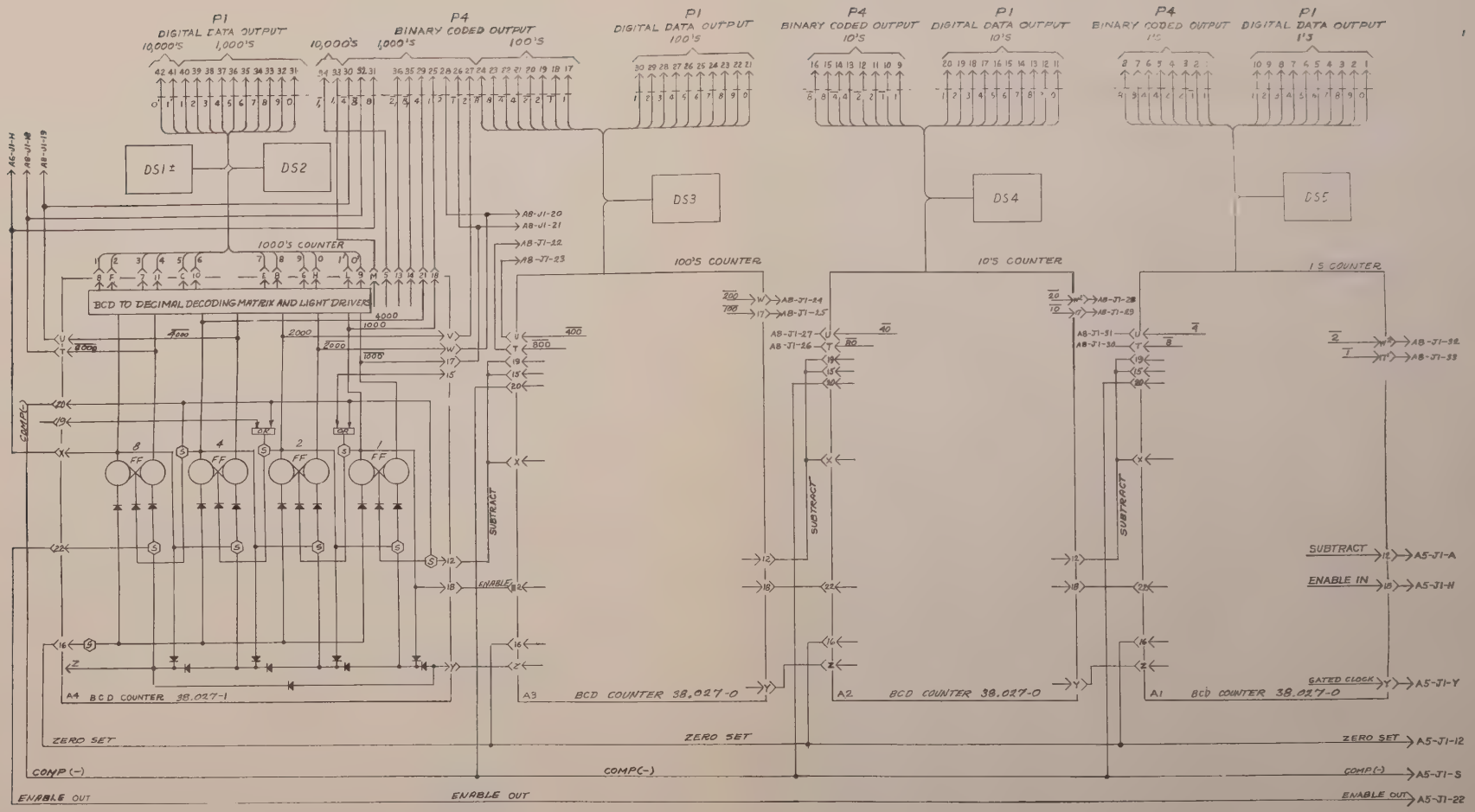
SHT NO.	2 3 4
SIZE	C D
REV NO.	0 1 16
PROJECT 1785	D 0216 203 25
SHEET	2

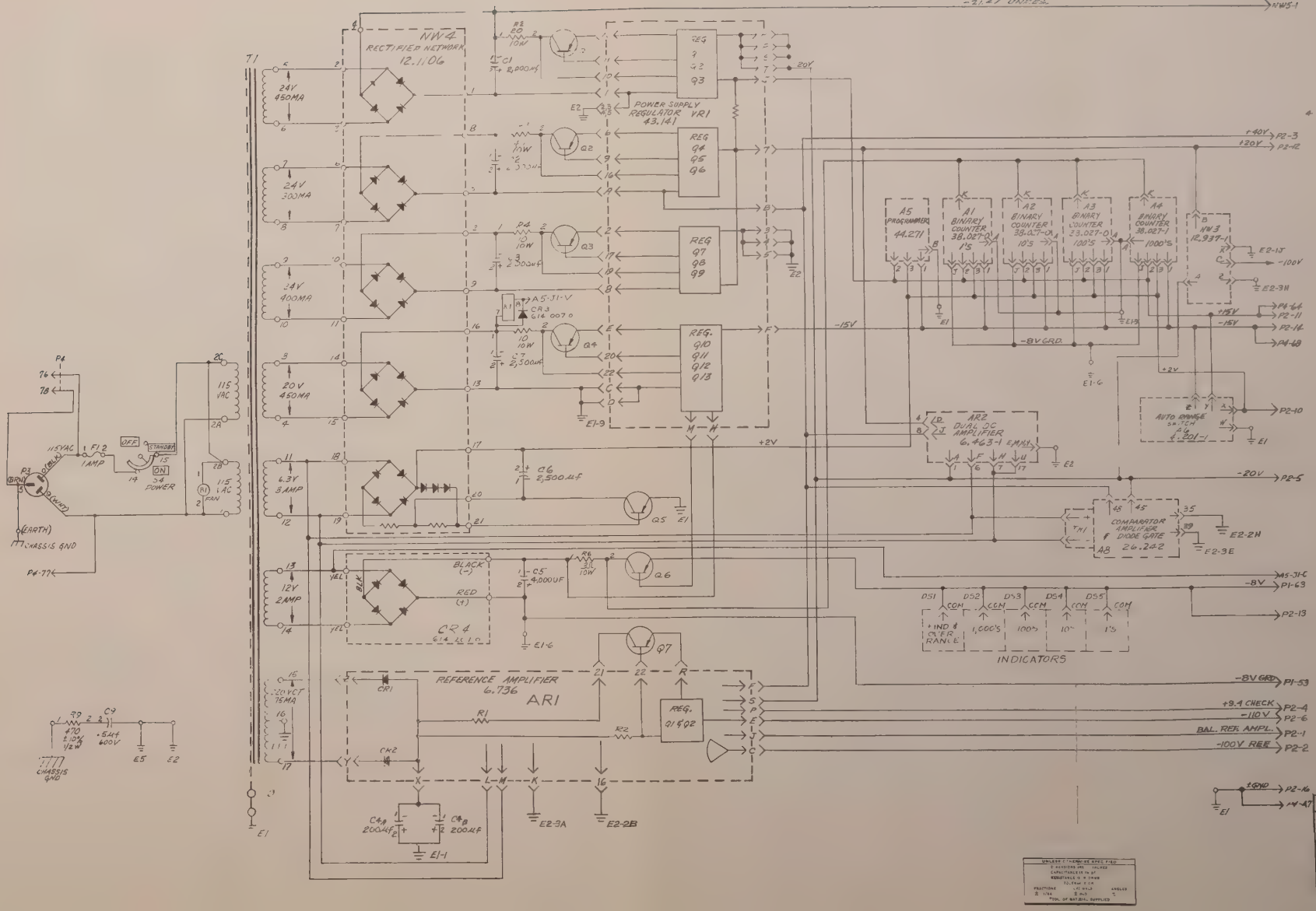


ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	D026 203 05
SHEET 2 OF	

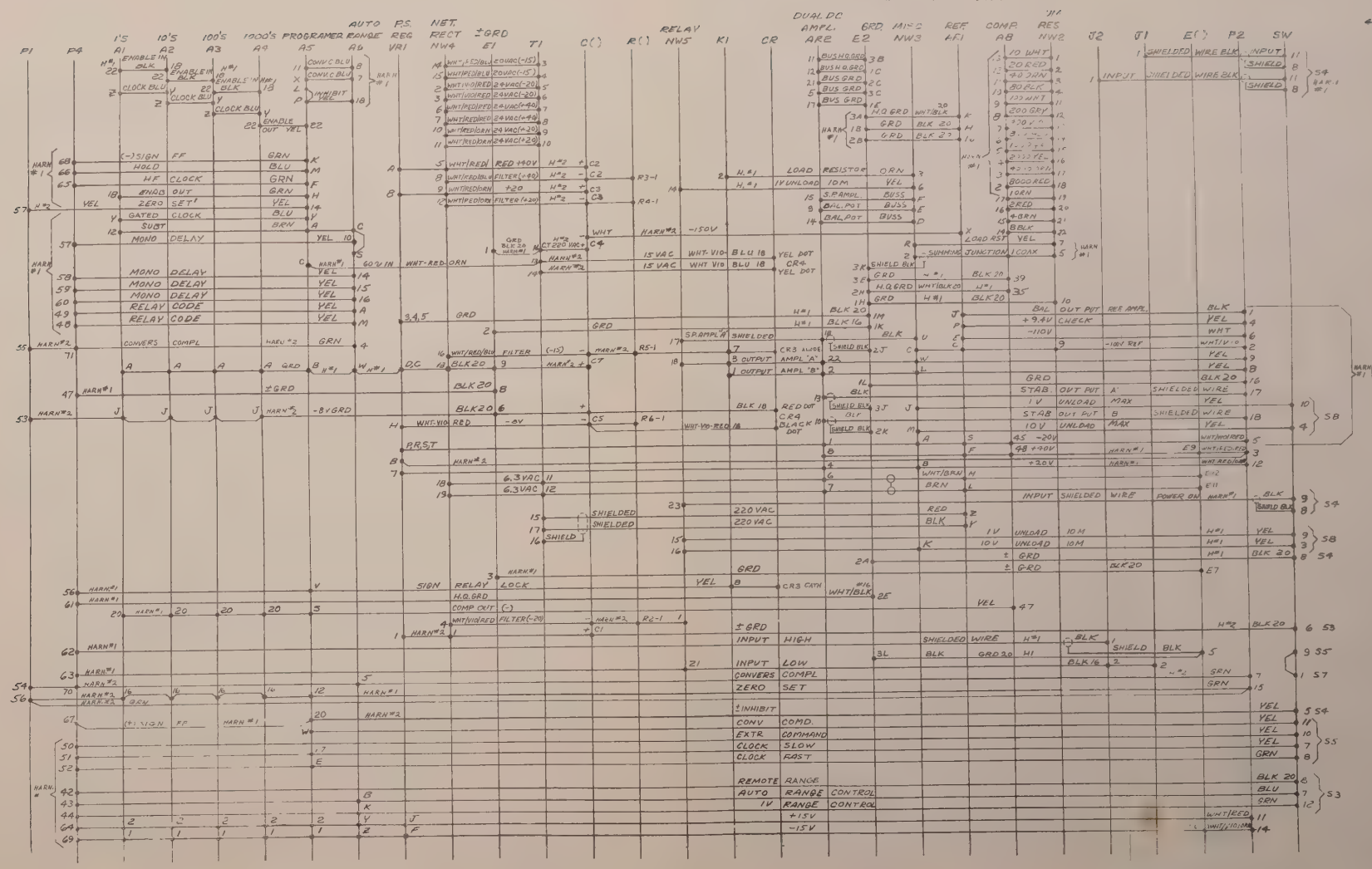


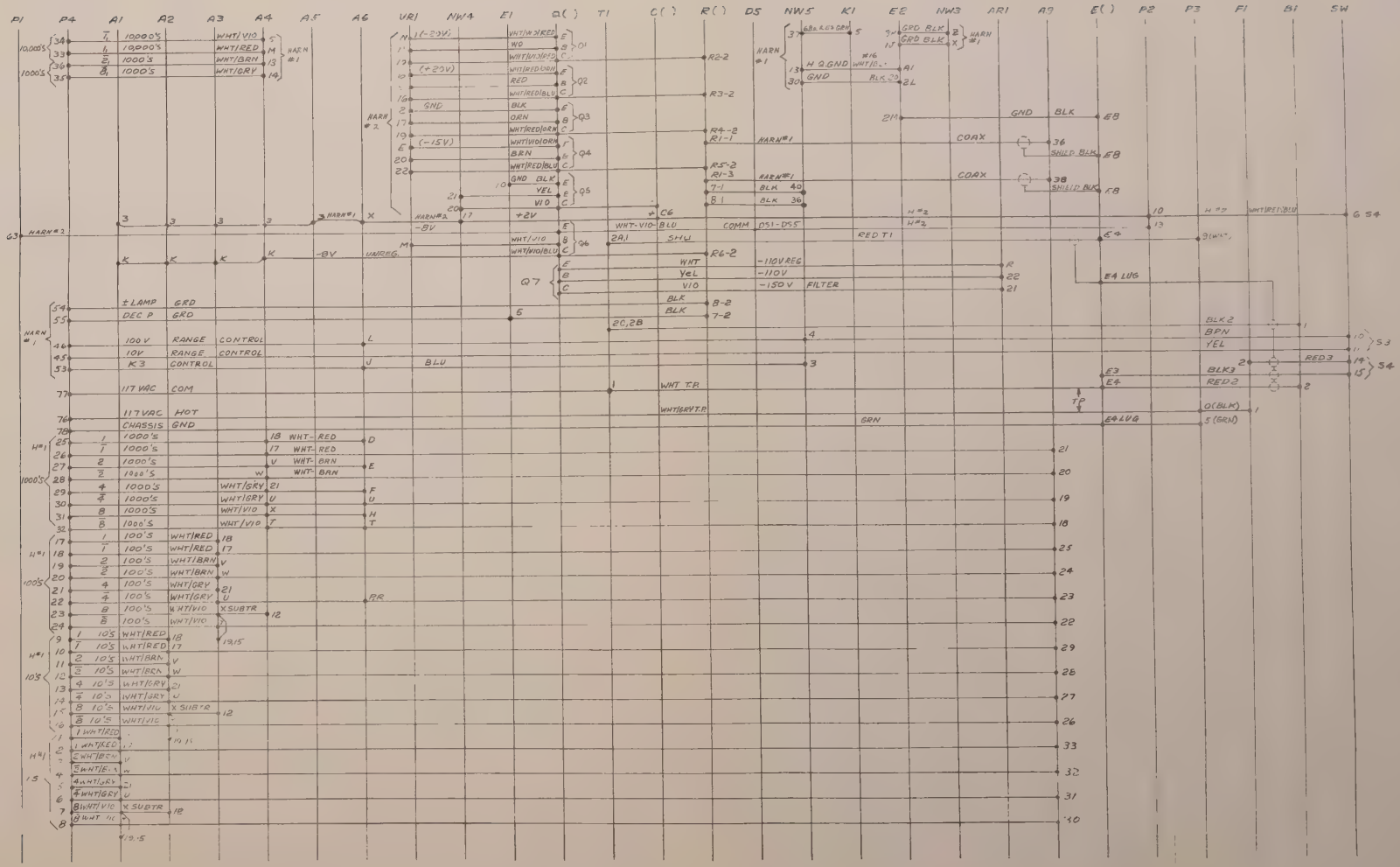
ELECTRONIC ASSOCIATES, INC.	LONG BRANCH, NEW JERSEY
SHT NO.	
SIZE	
REV NO.	
PROJECT 1723	D026 203 OS
SHEET 5 OF SHEETS	



ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

DWG. NO.	
SIZE	
REV. NO.	
PROJECT 1723	D266 B03 05


HARNESS #1 18663
HARNESS #2 18664
P1
P4
1'S A1
10'S A2
100'S A3
1000'S A4
PROGRAMER A5
AUTO RANGE A6
P.S. REG VR1
NET. RECT NW4
±GRD E1
T1
C()
R()
RELAY NW5
K1
CR
DUAL DC AMPL. ARE
GRD. IAI E2
NW3
REF AF1
COMP. AB
RES NW2
J2
J1
E()
P2
SW
ENABLE IN
CONV C BLU
INHIBIT
(-)SIGN
HOLD
MF CLOCK
ENAB OUT
ZERO SET
GATED CLOCK
SUBT
MONO DELAY
RELAY CODE
CONVERS COMPL
SIGN RELAY LOCK
COMP OUT (-)
INPUT HIGH
INPUT LOW
CONVERS COMPL
ZERO SET
±INHIBIT
CONV COMD.
EXTR COMMAND
CLOCK SLOW
CLOCK FAST
REMOTE RANGE
AUTO RANGE CONTROL
1V RANGE CONTROL
+15V
-15V
LOAD RESISTOR
10M POT
S.AMPL. POT
BAL. POT
SUMMING JUNCTION
AMPL "A" OUTPUT
AMPL "B" OUTPUT
220 VAC
6.3 VAC
±GRD
-8V GRD
+8V
-8V
+15 VAC
-15 VAC
+20 VAC
+200 VAC
-150V
+100V
+10V
+9.4V CHECK
-110V
-100V REF
STAB. OUT PUT
1V UNLOAD MAX
10V UNLOAD MAX
+2.0V
INPUT SHIELDED WIRE POWER ON
SHIELDED WIRE BLK
INPUT SHIELD BLK
SHIELD BLK
SHIELD
NOTE:
1. UNLESS OTHEWISE SPECIFIED
a. WIRE TO BE #24 GA PVC
b. BUSS TO BE 22 GA COVERED WITH EXTRUDED PLASTIC TUBING.
C. COAX WIRE B916 0010
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
WIRING
600/TDYM
SHT. NO. 2 3 4 5
SIZE C C C C
REV. NO. 4 4 3 3
PROJECT 1723
D026 203 0W



4

ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
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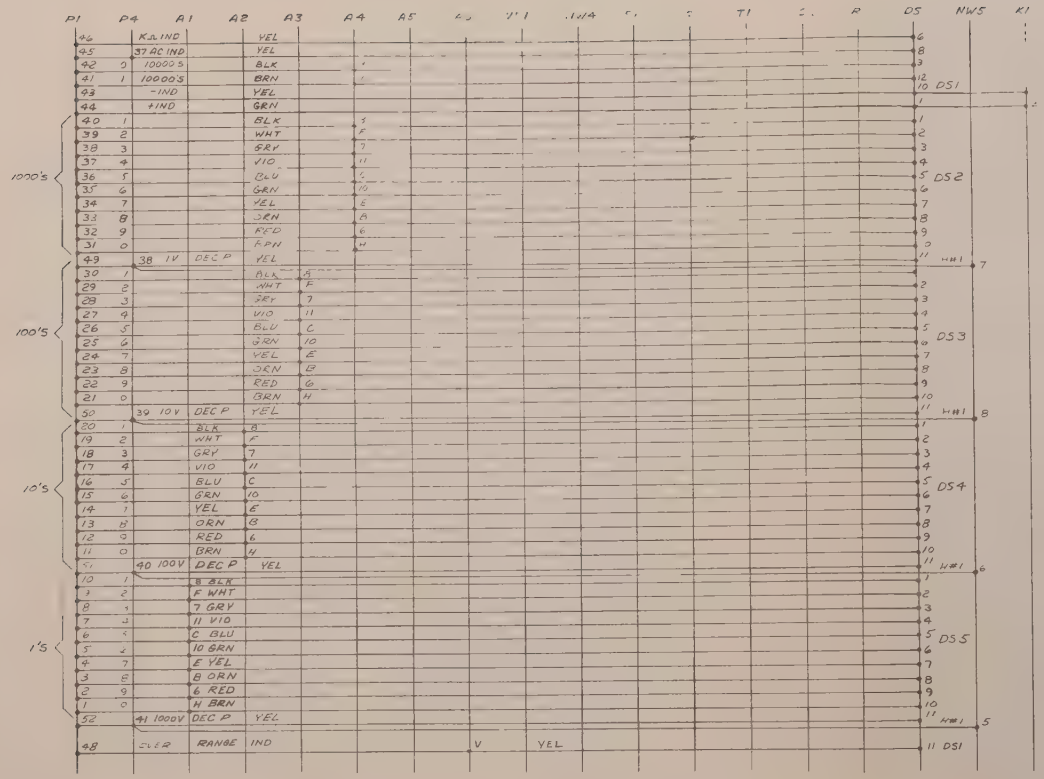
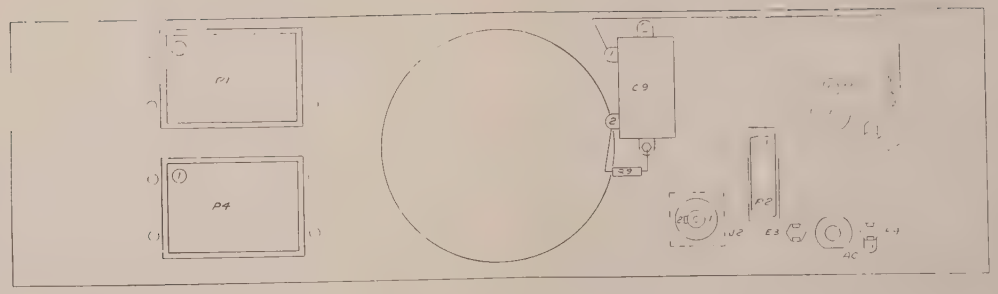
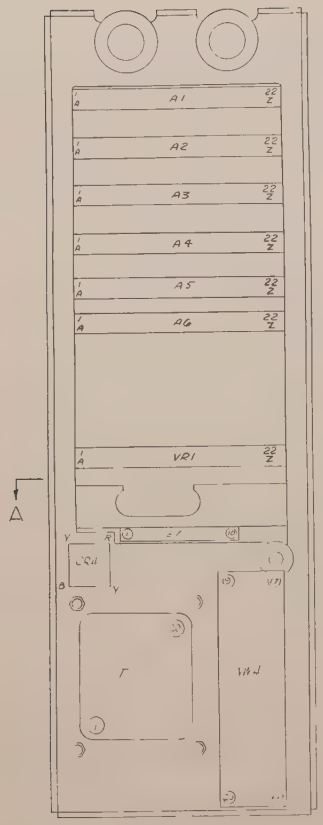
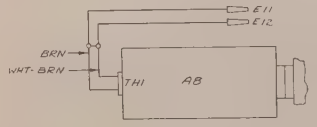
600I TDVM	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	D 026 283 OW
SHEET 2 OF	

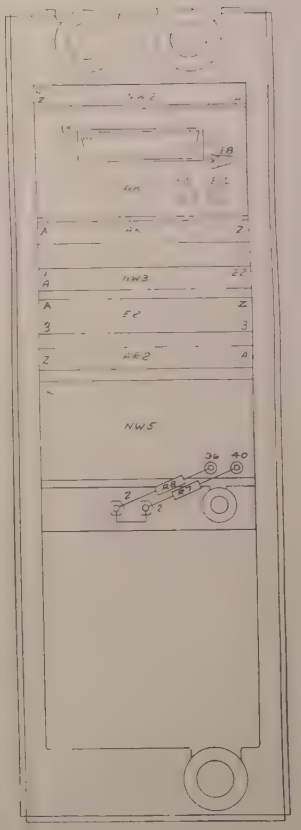


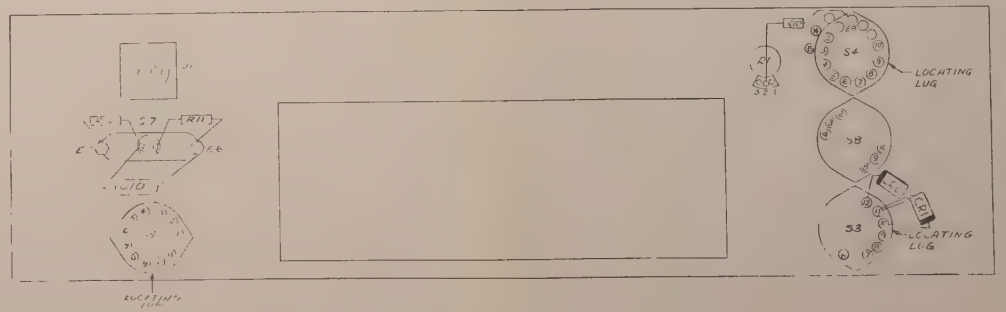
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
WIRING
6001 TDYM
SHT. NO.
SIZE
DEV. NO.
PROJECT 1723
D 026 203 ON









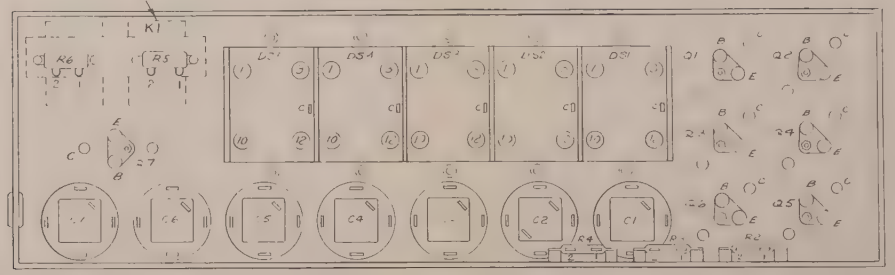


ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
WIRING	
600i TDVM	
DWT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	D 026 203 0W

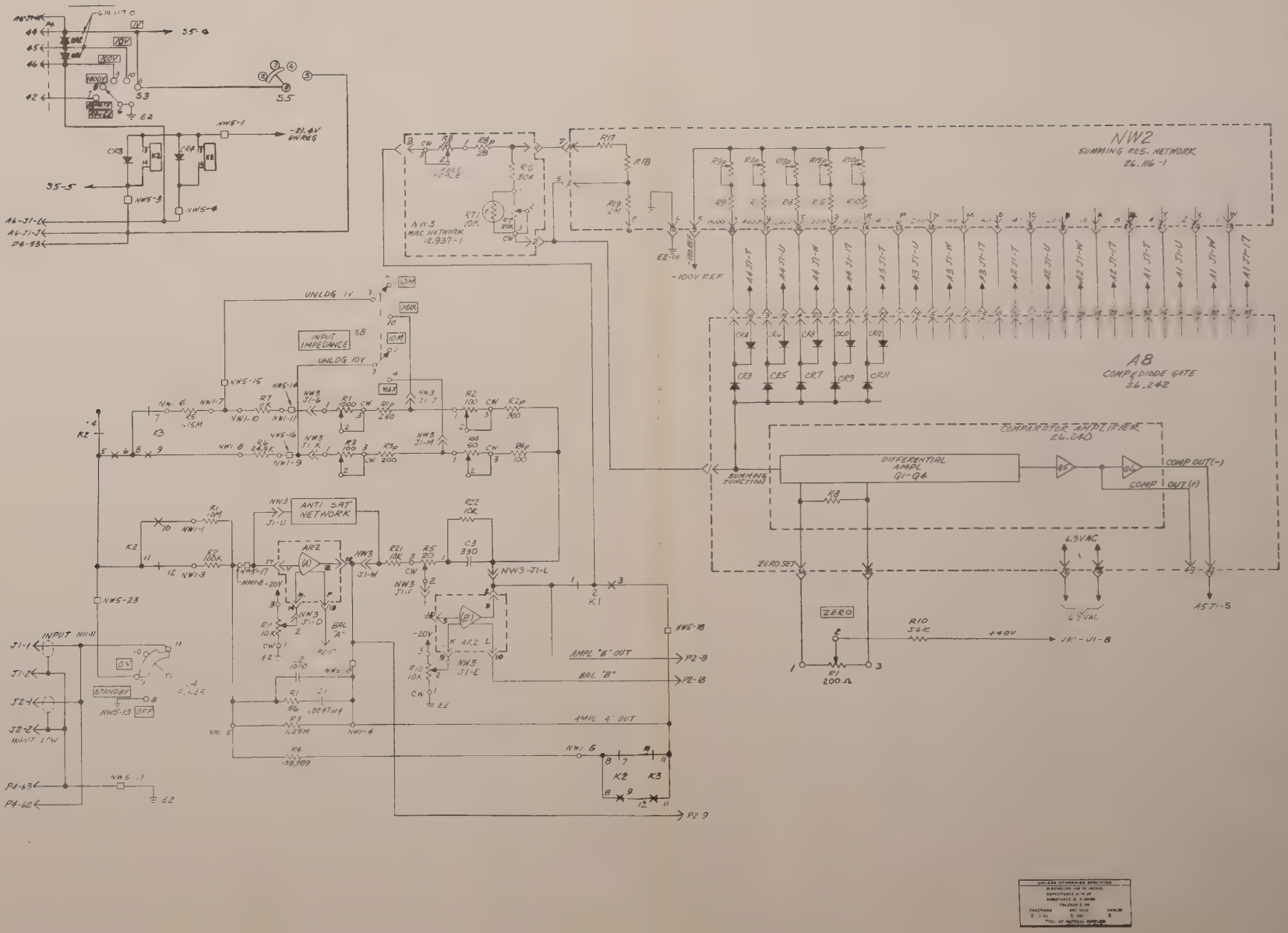
DETAIL "A"
TOP VIEW

SEE DETAIL "A"

VIEW A-A



ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
SHT NO	
SIZE	
REV NO	
PROJECT 1723	D 026 203 OW
SHEET # OF SHEETS	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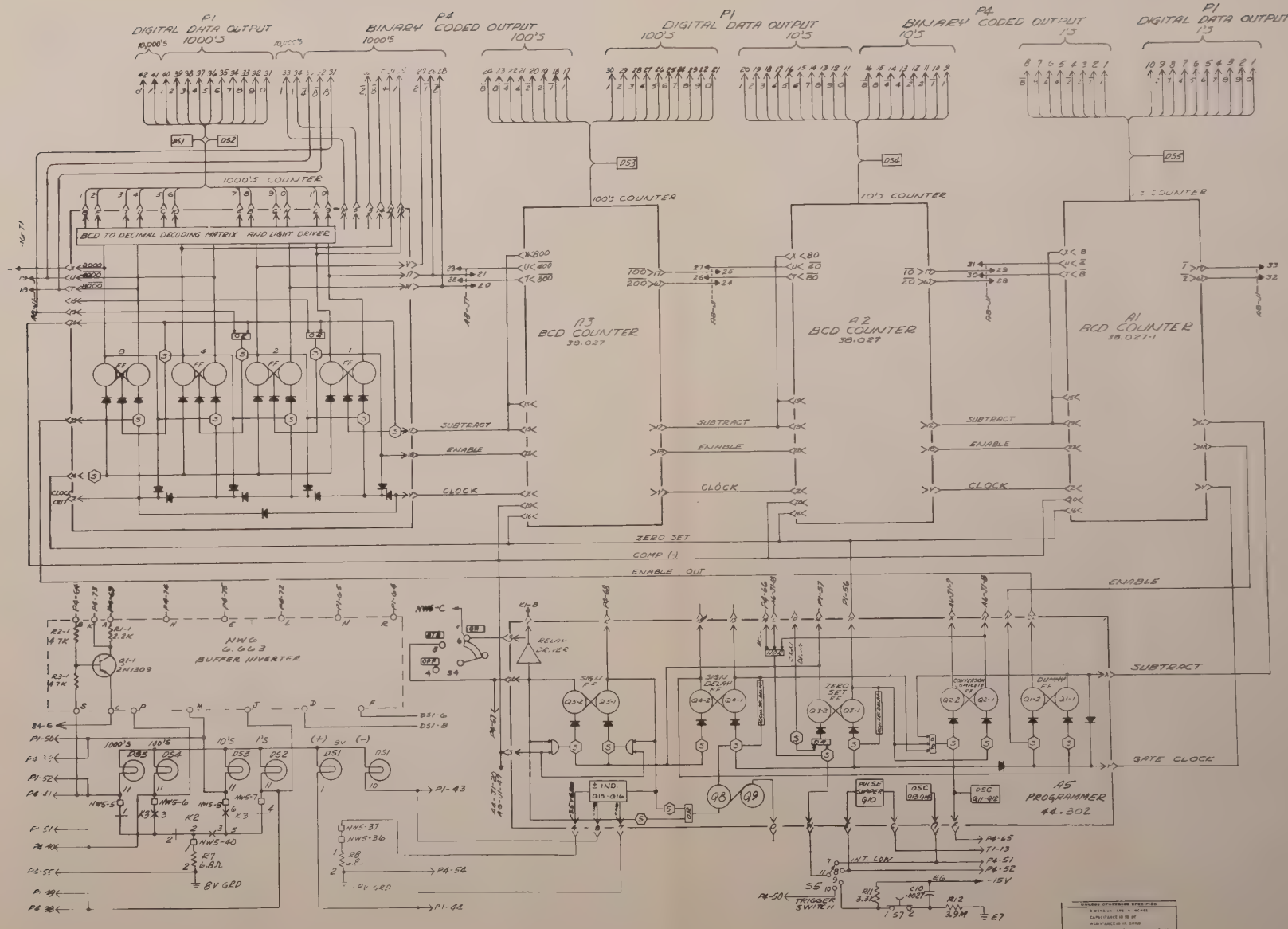
SUMMING RES. NETWORK
26.116-1
A8
COMP. DIODE GATE
26.242
COMPARATOR AMPLIFIER
26.240
DIFFERENTIAL AMPL
Q1-Q4
SUMMING JUNCTION
COMP OUT(-)
COMP OUT(+)
ZERO SET
ZERO
6.3VAC
+40V
-100V REF
ANTI SAT NETWORK
INPUT IMPEDANCE
UNLOG 1V
UNLOG 10V
AMPL "A" OUT
AMPL "B" OUT
BAL "A"
BAL "B"
INPUT HI-II
STANDBY
ELECTRONIC ASSOCIATES INC.
LONG BRANCH NEW JERSEY
EMOTIC
6000 DYM
D086257 05



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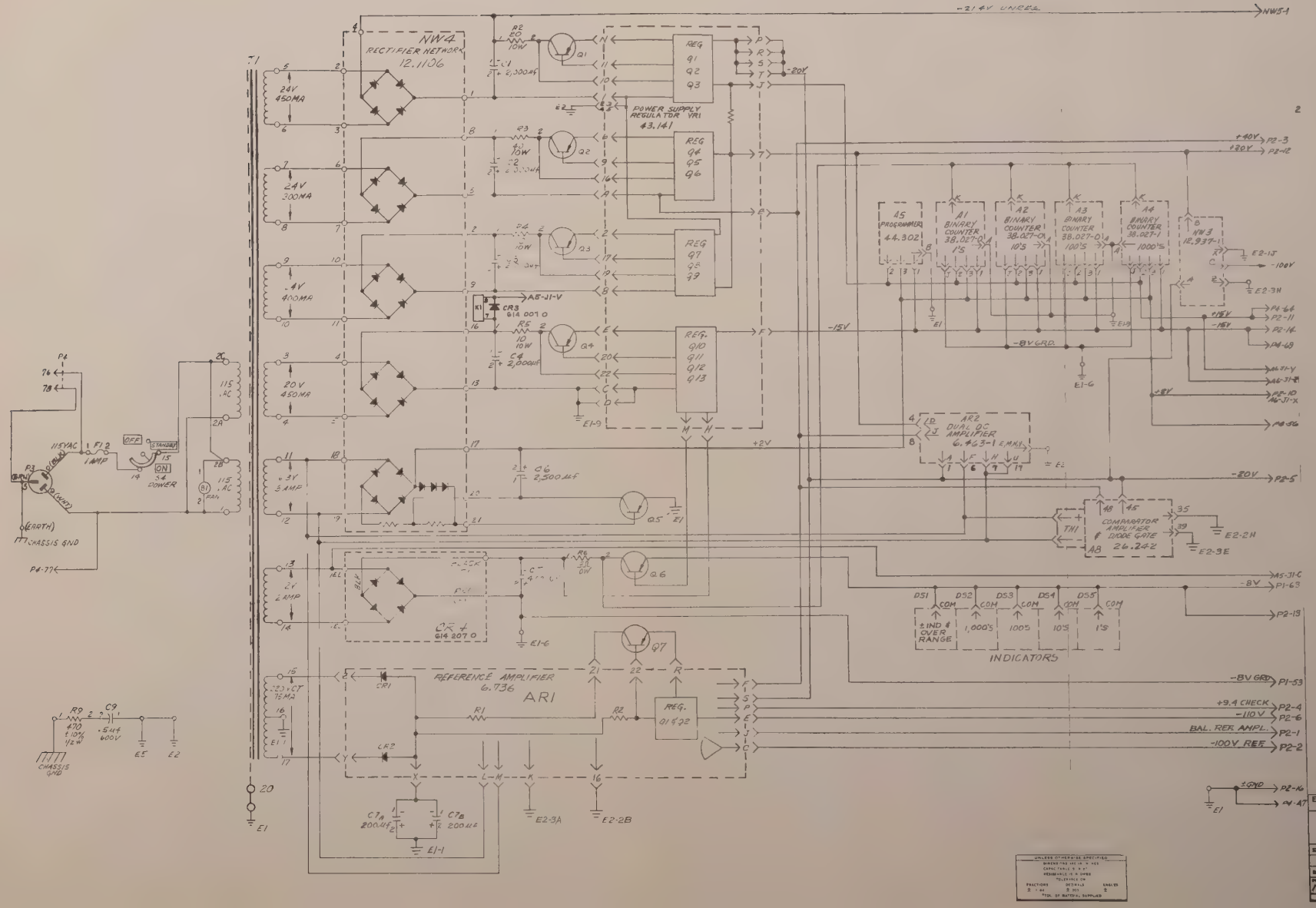
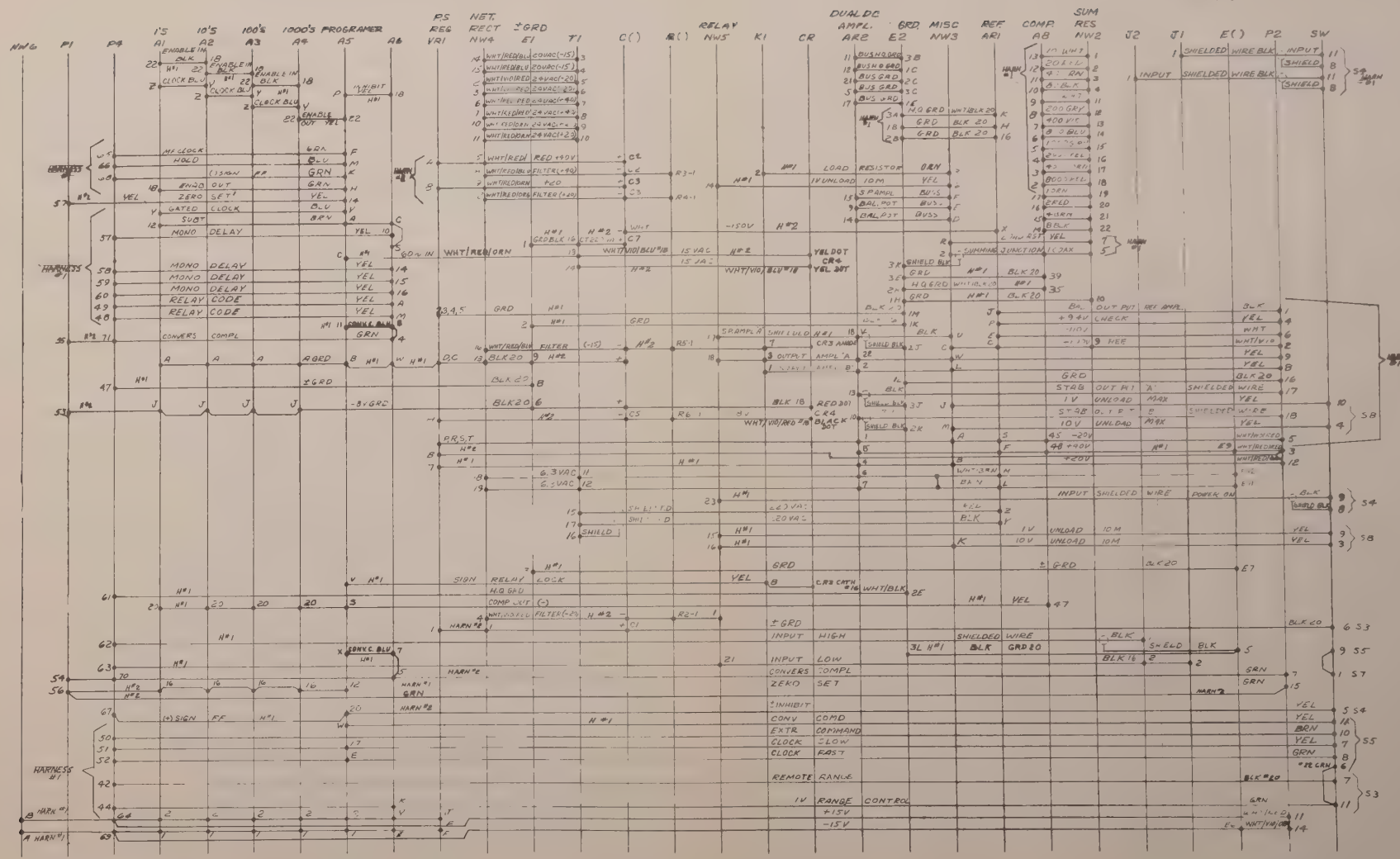
SHT NO	
SIZE	
REV. NO.	
PROJECT 1723	D026 257 05



ELECTRONIC ASSOCIATES INC.	LONG BRANCH, NEW JERSEY
DWT. NO.	
SIZE	
REV NO.	
PROJECT 1723	D0286257 05

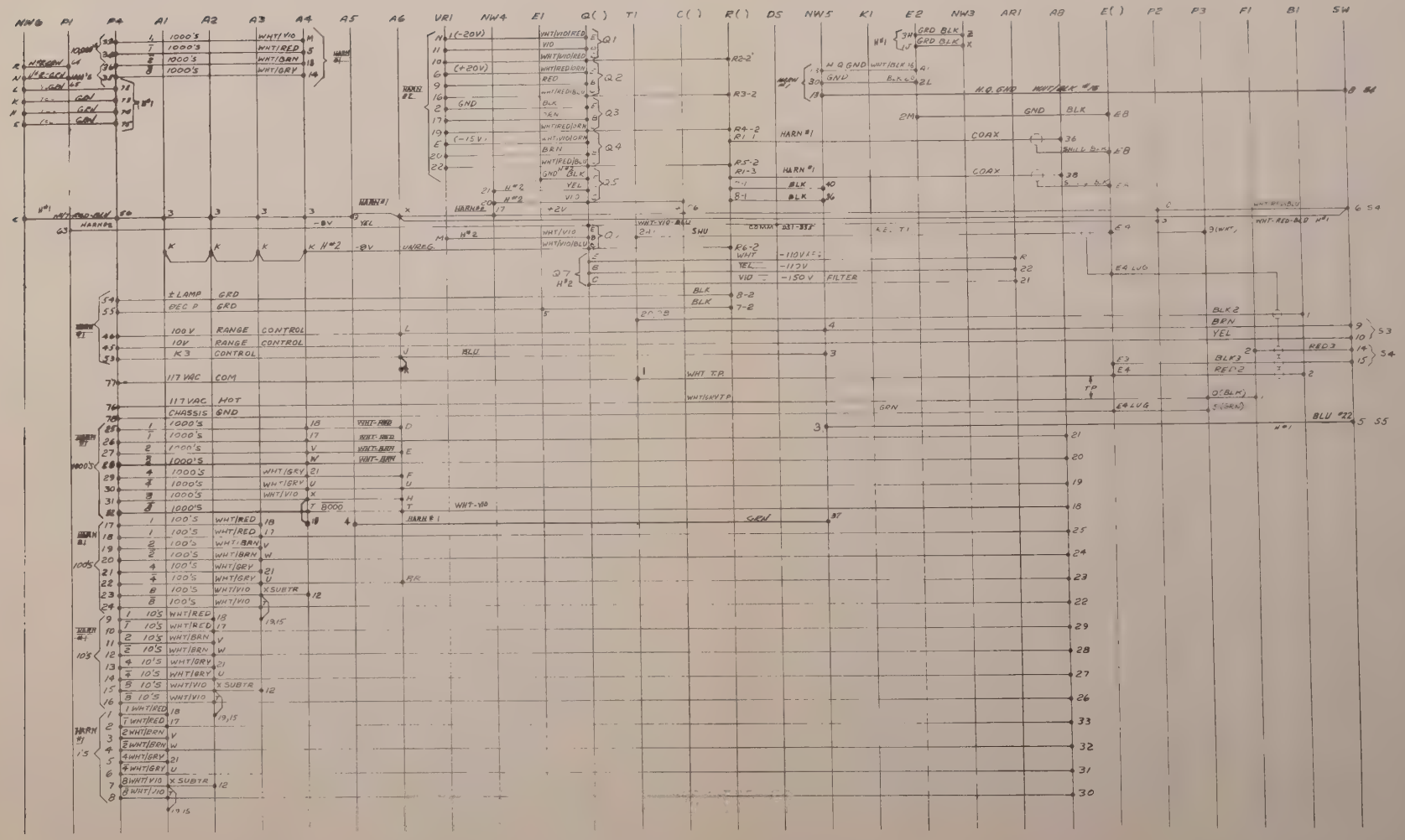


NOTES:
1. UNLESS OTHERWISE SPECIFIED
   a. WIRE TO BE #24 GA PVC
   b. BUSS TO BE #22 INSULATED WITH EXTRUDED PLASTIC TUBING
   c. COAX WIRE B916 0010

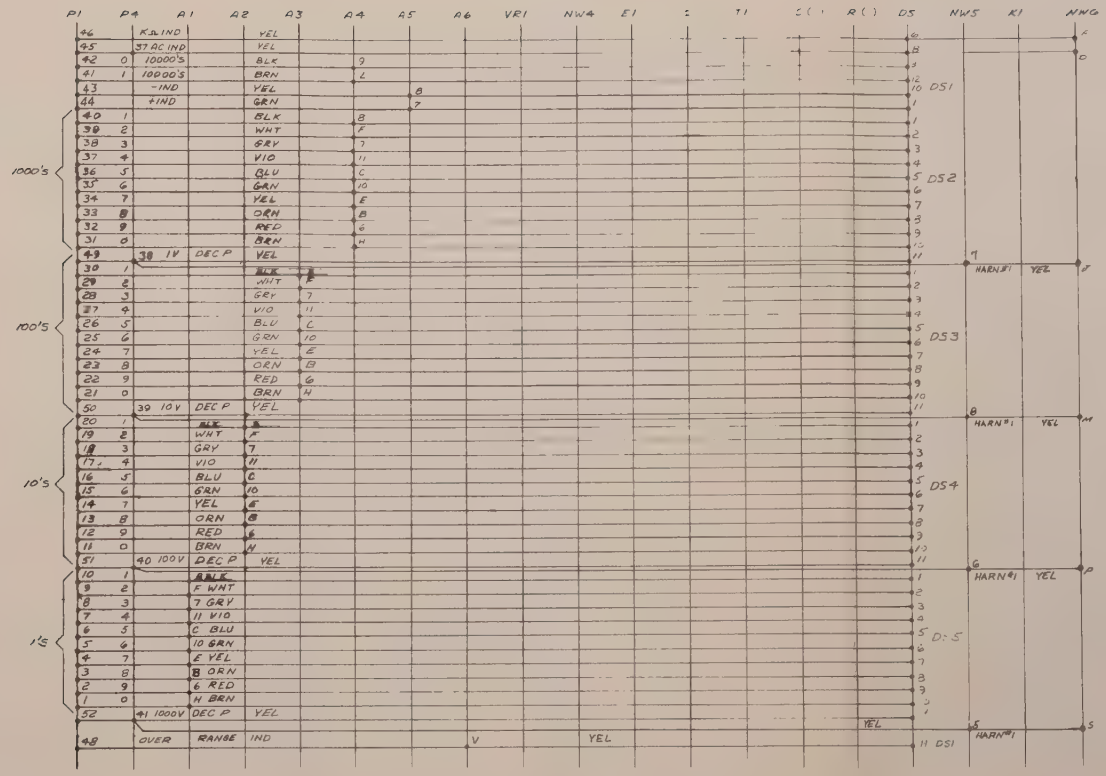
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

WIRING

SHT. NO. 2 3 4 5
SIZE D
REV. NO. 2 2 E1
PROJECT 1723 D026257 0W



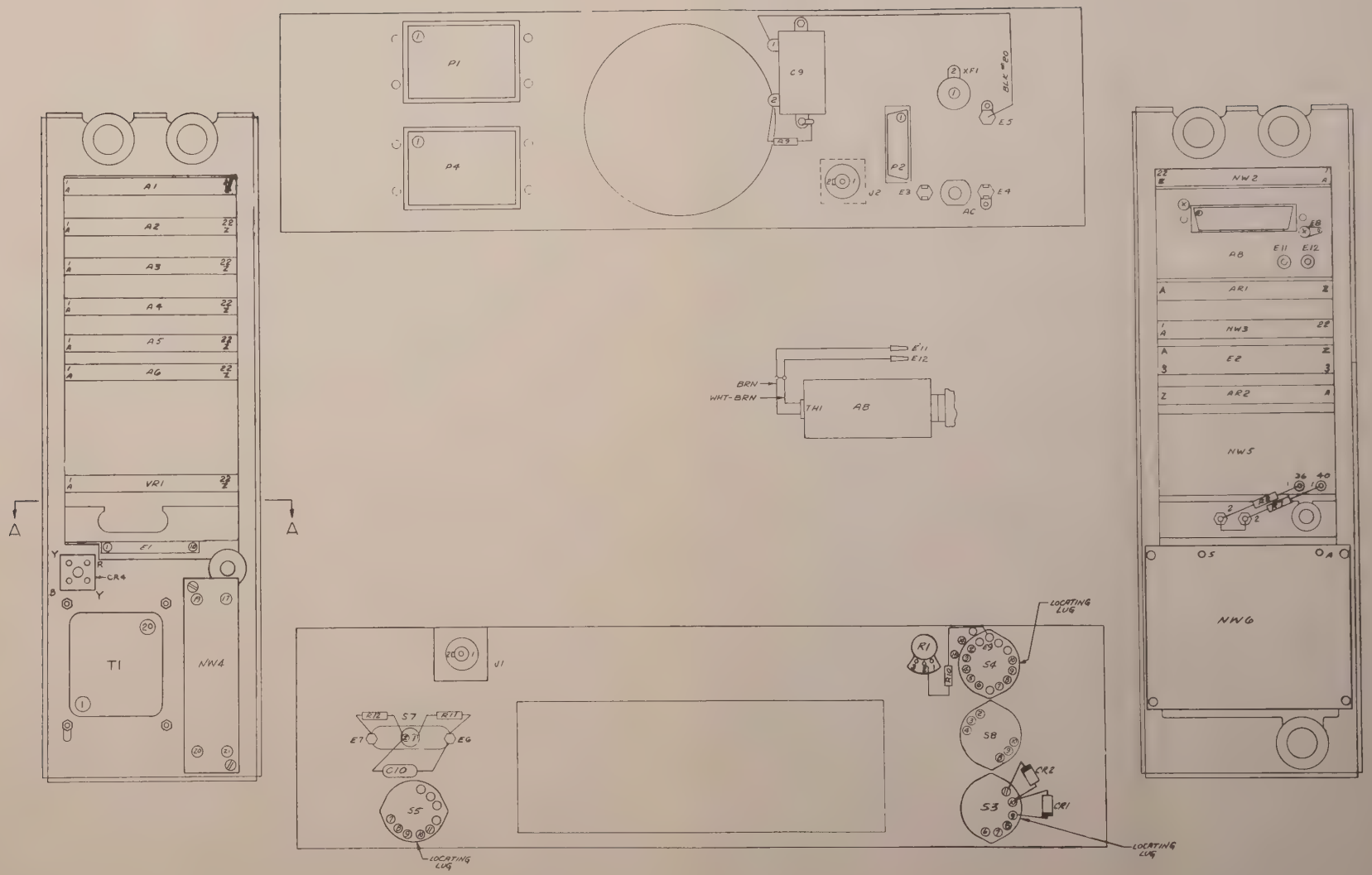
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
DWG. NO.
SIZE
REV NO.
PROJECT 1723 D026257 0W
SHEET 2 OF



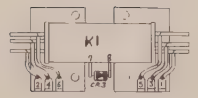
NOTE 1. UNLESS OTHERWISE SPECI'D ALL WIRES ON THIS SHEET ARE IN HARNESS # 2 (10 664)

12

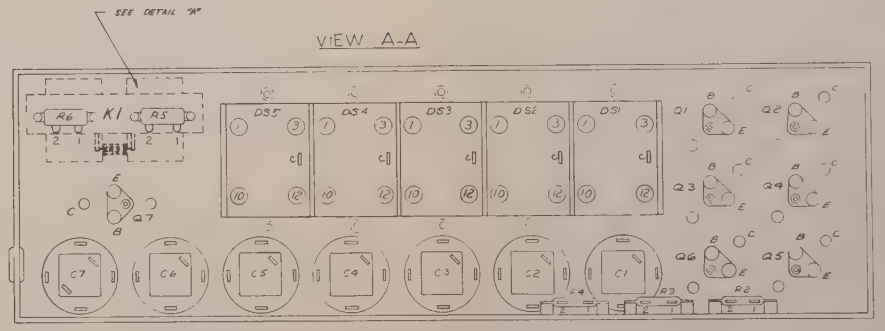
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
DWT NO.
SIZE
REV NO.
PROJECT 1723
D 026 857 OW
SHEET OF



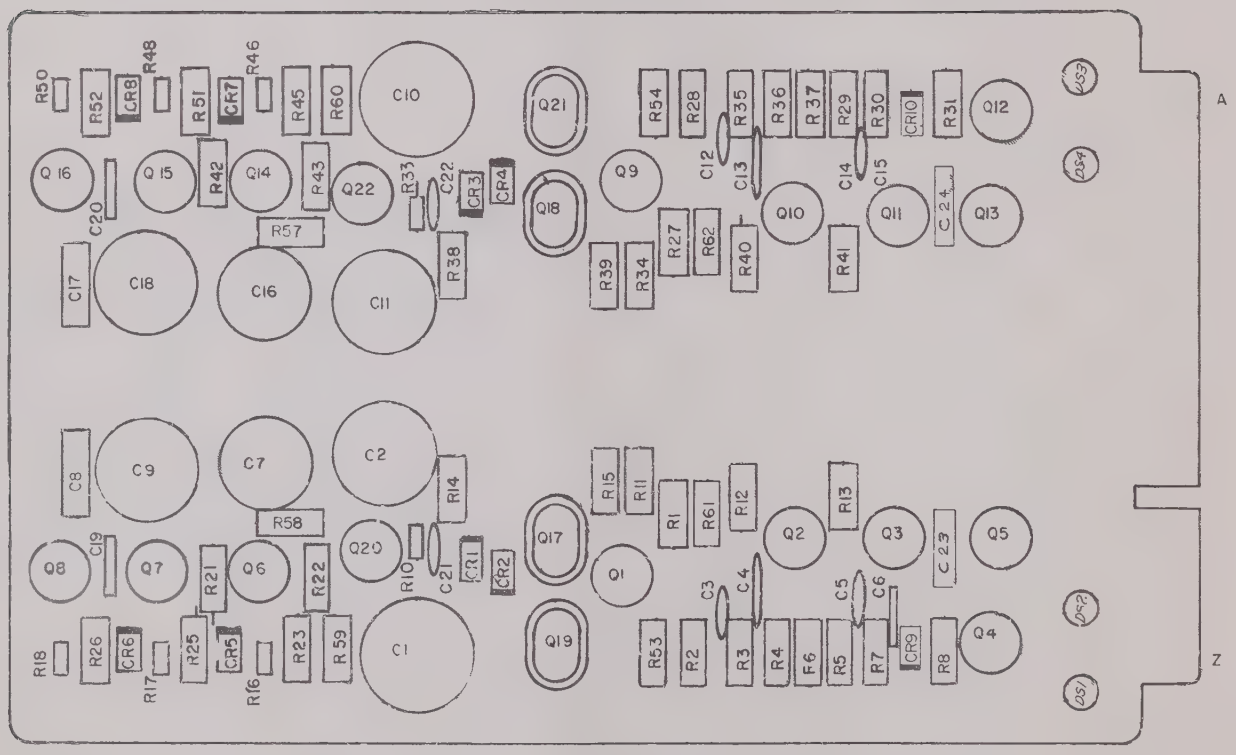
ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
DWT NO.	
SIZE	
REV NO.	
PROJECT 1723	D 026 857 OW
SHEET 2 OF	



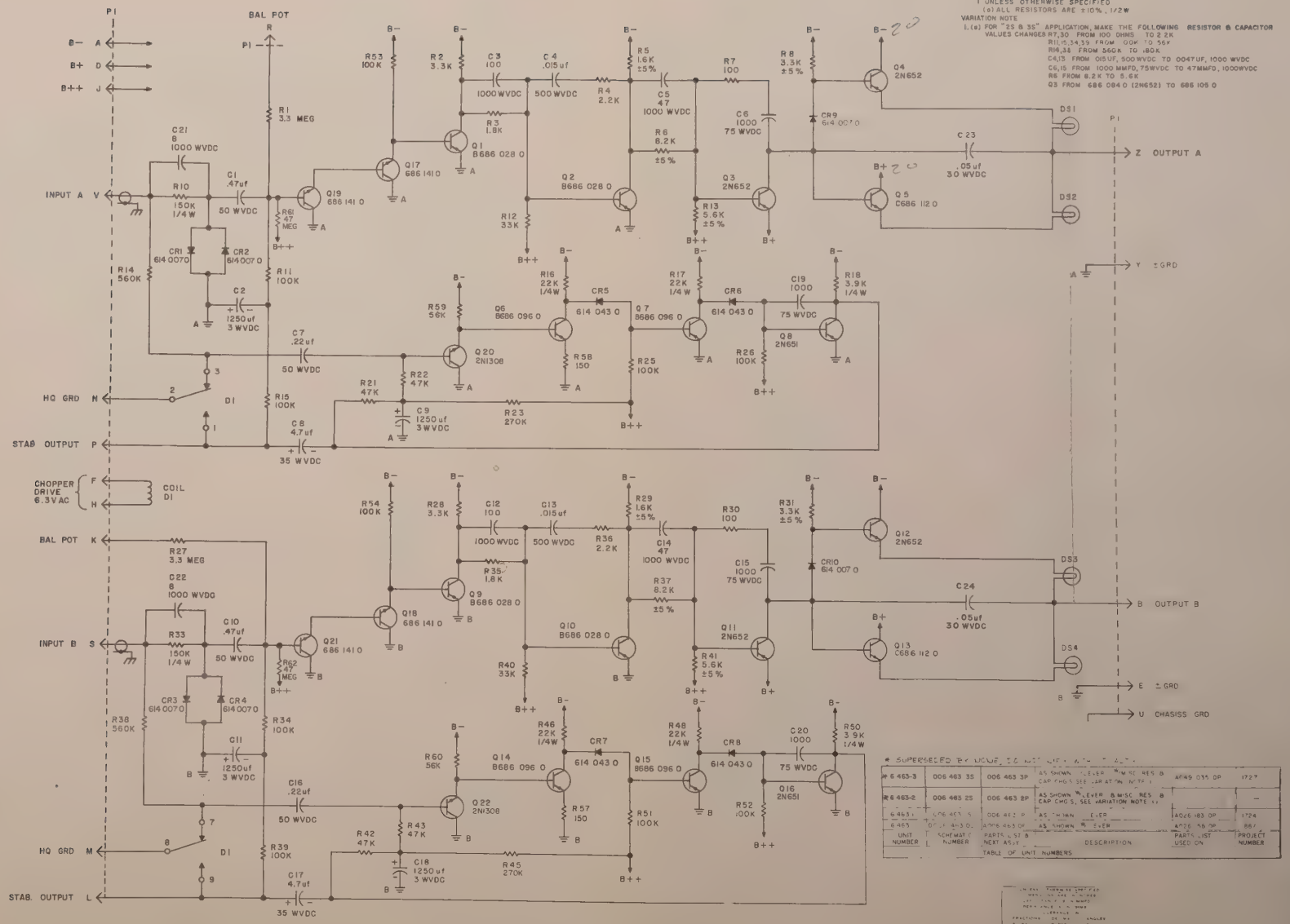
DETAIL "A"
TOP VIEW



ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SHT NO.
SIZE
REV NO.
PROJECT
1723
D 026657 000
SHEET OF



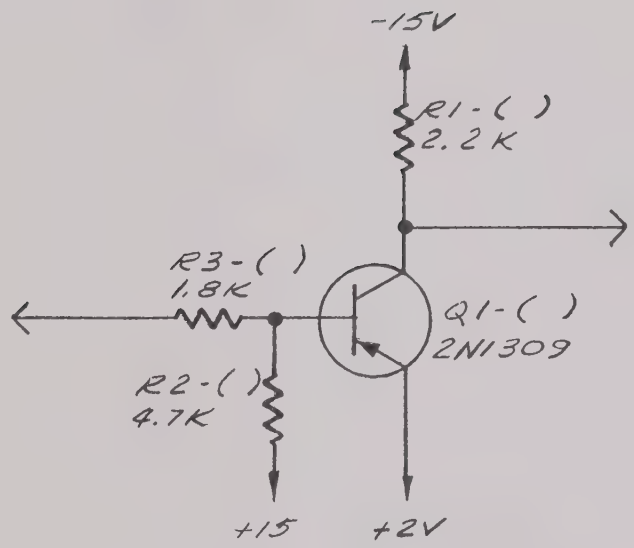
6.463 Dual DC Amplifier


NOTES
1 UNLESS OTHERWISE SPECIFIED
(a) ALL RESISTORS ARE ±10%, 1/2W
VARIATION NOTE
1. (a) FOR "35 & 38" APPLICATION, MAKE THE FOLLOWING RESISTOR & CAPACITOR VALUES CHANGES R7,30 FROM 100 OHMS TO 2.2K
R11,15,34,39 FROM 100K TO 56K
R14,38 FROM 560K TO 180K
C4,13 FROM .015UF, 500 WVDC TO .0047UF, 1000 WVDC
C6,15 FROM 1000 MMFD, 75WVDC TO 47MMFD, 1000WVDC
R6 FROM 8.2K TO 5.6K
Q3 FROM 686 084 0 (2N652) TO 686 105 0
P1
BAL POT
INPUT A
INPUT B
HQ GRD
STAB OUTPUT
CHOPPER DRIVE 6.3VAC
COIL D1
OUTPUT A
OUTPUT B
Y ± GRD
E ± GRD
U CHASISS GRD
Q1 B686 028 0
Q2 B686 028 0
Q3 2N652
Q4 2N652
Q5 C686 112 0
Q6 B686 096 0
Q7 B686 096 0
Q8 2N651
Q9 B686 028 0
Q10 B686 028 0
Q11 2N652
Q12 2N652
Q13 C686 112 0
Q14 B686 096 0
Q15 B686 096 0
Q16 2N651
Q17 686 141 0
Q18 686 141 0
Q19 686 141 0
Q20 2N1308
Q21 686 141 0
Q22 2N1308
CR1 614 007 0
CR2 614 007 0
CR3 614 007 0
CR4 614 007 0
CR5 614 043 0
CR6 614 043 0
CR7 614 043 0
CR8 614 043 0
CR9 614 007 0
CR10 614 007 0
DS1
DS2
DS3
DS4
* SUPERSEDED BY DCUE, DO NOT USE WITH
UNIT NUMBER
SCHEMATIC NUMBER
PARTS LIST NEXT ASY
DESCRIPTION
PARTS LIST USED ON
PROJECT NUMBER
TABLE OF UNIT NUMBERS
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SCHEMATIC
DUAL D.C AMPLIFIER
DWT NO
SIZE
REV
PROJ NO
1887
D006 463 0S
SHEETS

6.663 Buffer Inverter (6000 TDVM)

NOTES:
1. UNLESS OTHERWISE SPECIFIED
   (a) RESISTORS ARE ±10%, 1/2W
   (b) FOR COMPLETE COMPONENT REF. DESIGNATION, ADD STAGE NUMBER IN PARENTHISIS, IE R1-(2).

-15V A ⟷
+15V B ⟷
+2V C ⟷

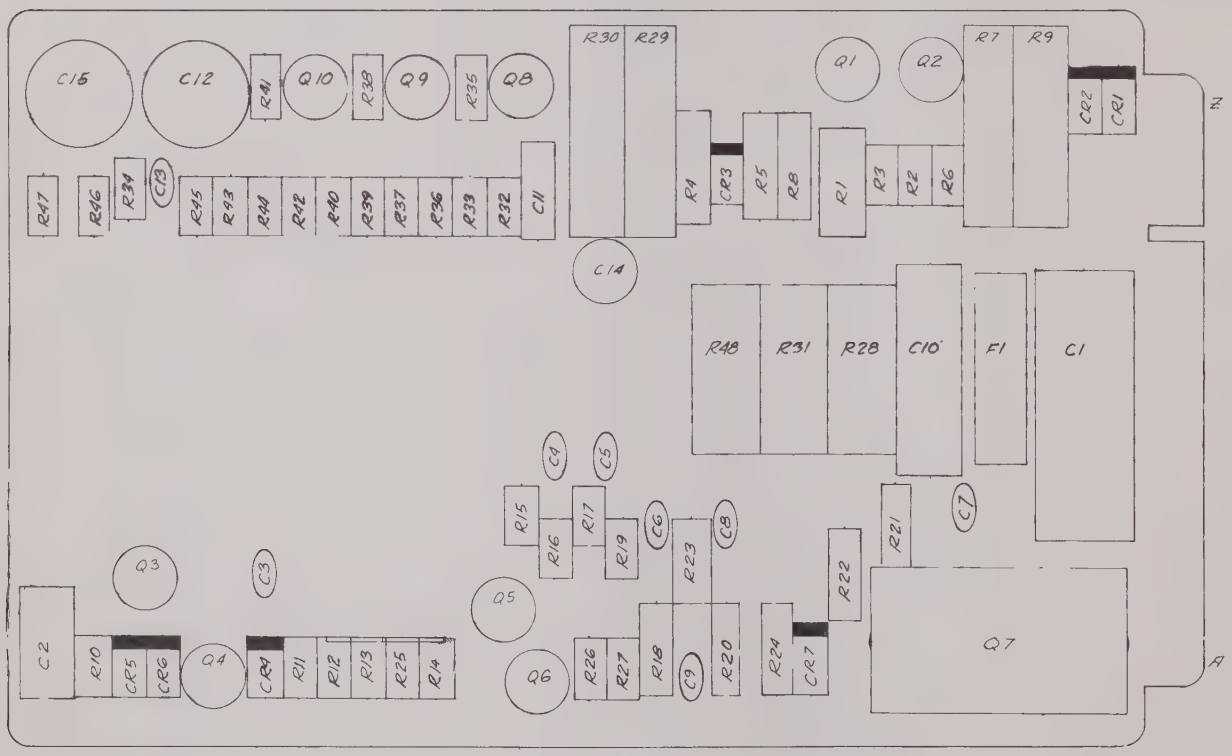


TERM.	STAGE
K	1
H	2
E	3
L	4
N	5
R	6

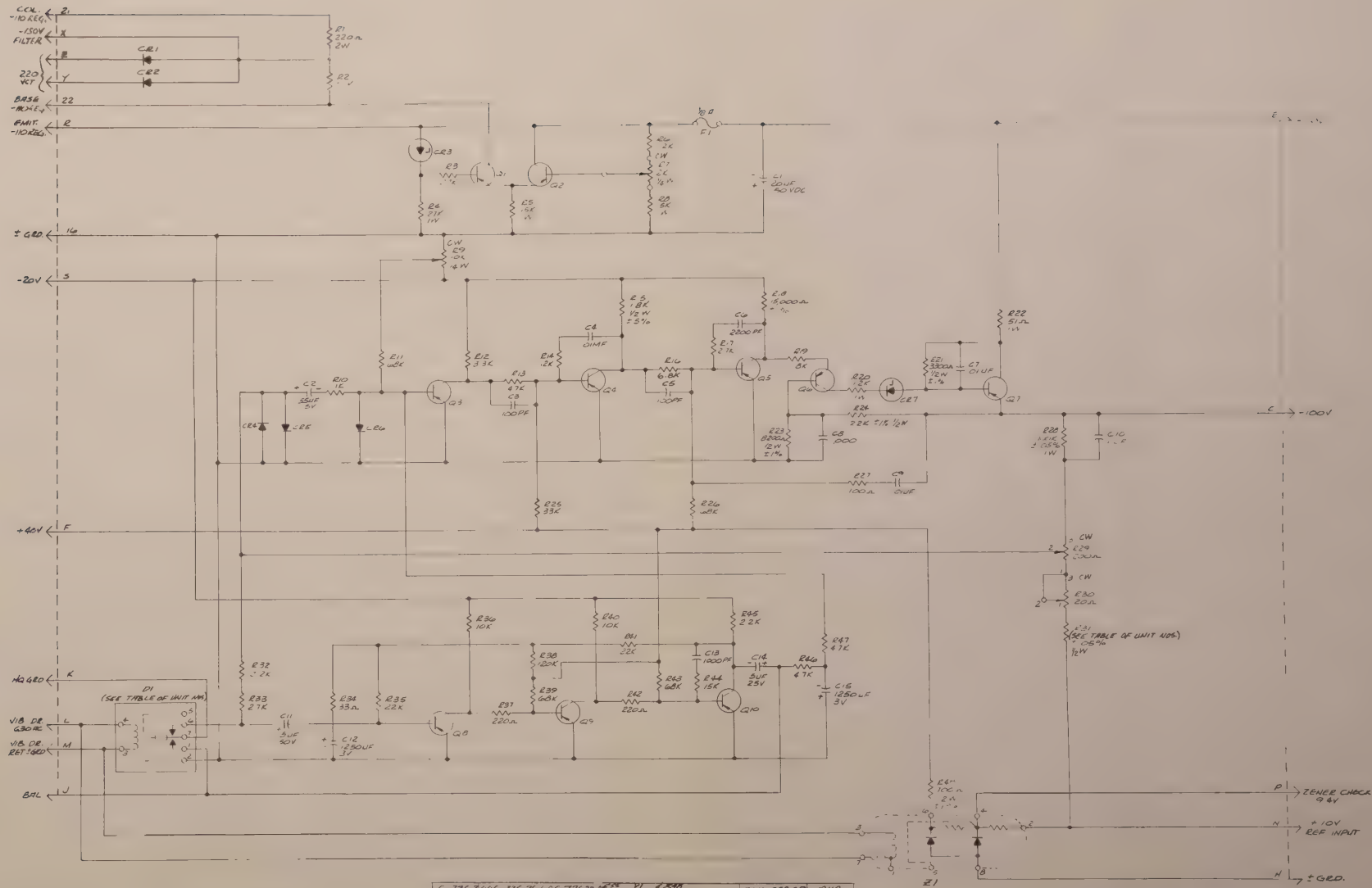
STAGE	TERM
1	J
2	F
3	D
4	M
5	P
6	S

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN pf
RESISTANCE IS IN OHMS
TOLERANCE OF: .X = ± .03 .XX = ± .02 .XXX = ± .015 .XXX = ± 005 ∠ = ± 1°
* TOL. OF MATERIAL SUPPLIED

ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
SCHEMATIC BUFFER INVERTER (6000 TDVM)	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	A006663 05
SHEET / OF / SHEETS	



6.736 Reference Amplifier P.S. (TDVM TR-48)



UNIT NUMBER	SCHEMATIC NUMBER	PARTS LIST & NEXT ASSY	DESCRIPTION	PARTS LIST USED ON	PROJECT NUMBER
6.736-3	006 736 35	006 736 3P	D1 = 530 064 ; R31 = 16K	A010 259 0P	19110
6.736-2	006 736 85	006 736 2P	D1 = 530 064 ; R31 = 8.94K		
6.736	006 736 15	006 736 1P	D1 = 530 003 0 ; R31 = 10K	A010 259 0P	19110
6.736	D006 736 05	A006 736 0P	D1 = 530 003 0 ; R31 = 8.76K		

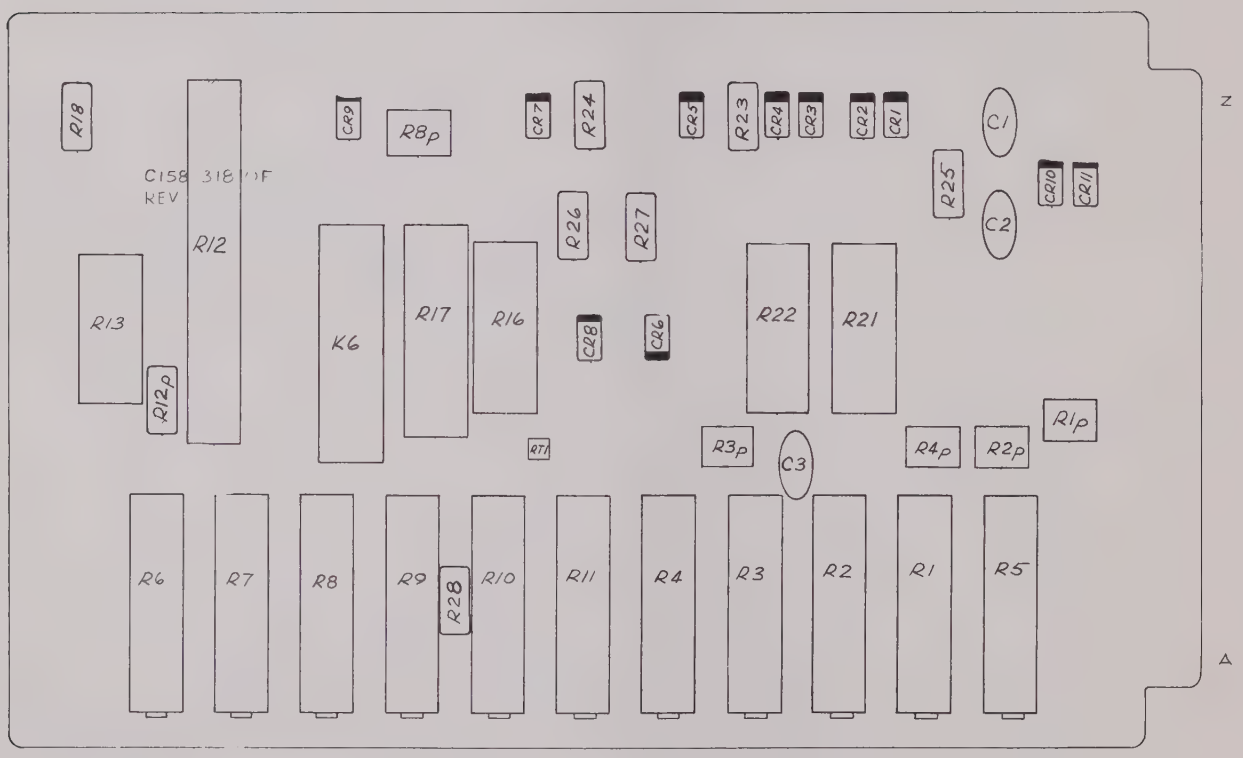
TABLE OF UNIT NUMBERS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN μF
RESISTANCE IS IN Ω
TOLERANCES ON
FRACTIONS ±1/64 | DECIMALS ±.01 | ANGLES ±1°
TOOL OF MATERIAL SUPPLIED

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

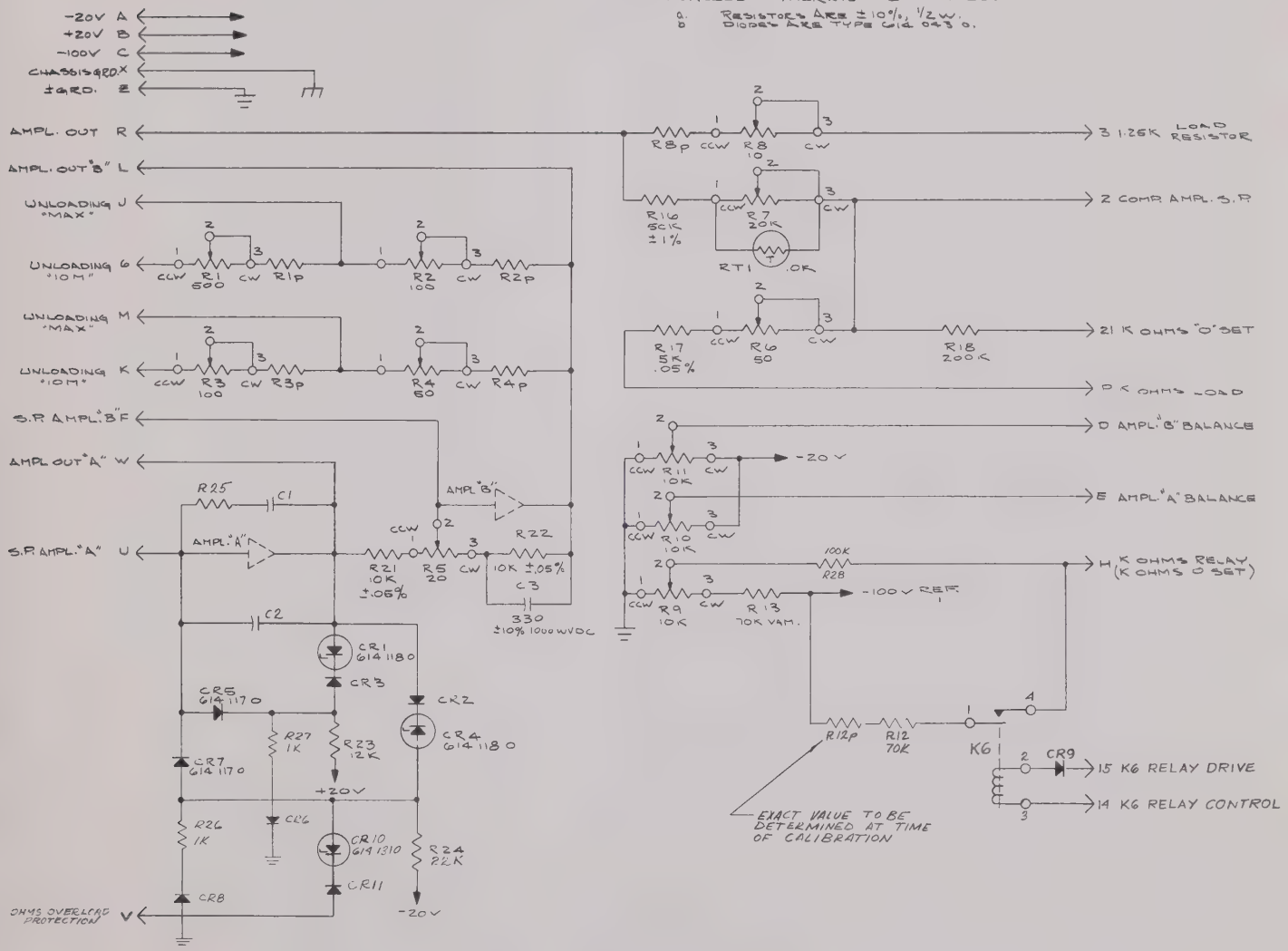
SCHEMATIC REFERENCE AMPLIFIER (TYPE TR-48)

UNIT NO.
SIZE
REV. NO.
PROJECT 1725
D006 736 05



12.937 Miscellaneous Network (6001 TDVM)

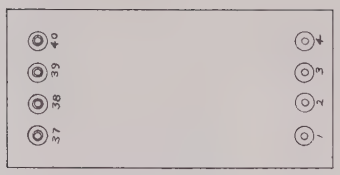
NOTE:
1. UNLESS OTHERWISE SPECIFIED:
   a. RESISTORS ARE ±10%, 1/2 W.
   b. DIODES ARE TYPE GIA 043 O.

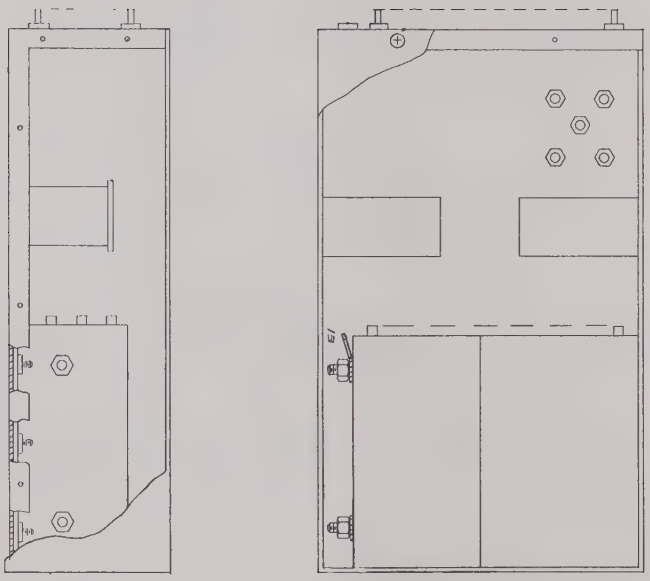


12.937-4	C012 937 4S	C012 937 4D	OMIT C1, 2; R25; R12 IS 25 MEG, R18 IS 100 K.	A026 262 OP	1723
12.937-3	C012 937 3S	C012 937 3P	OMIT R27, C1, 2, CR1, 2, 3, 4, 5, 7, 10, 11, R23, R24, R26, CR8 & R28	A026 261 OP	1723
12.937-2	C012 937 2S	C012 937 2P	OMIT R21, 22, R16, R7, R5, R17, R18, R6, C3, CR1, 2, 3, 4, 5, 7, 8, 10, 11, R23, R24, R26, R27, R28, K12, K10, K6 & CR9	—	19110
12.937-1	C012 937 1S	C012 937 1P	OMIT R16, R7, R5, R17, R18, R6, C3, CR1, 2, 3, 4, 5, 7, 8, 10, 11, R23, R24, R26, R27, R28, K12, K10, K6 & CR9	A 026 203 OP	1723
12.937	C012 937 0S	A012 937 0P	OMIT C1, 2; R25 & 28	—	1723
SCHEMATIC					

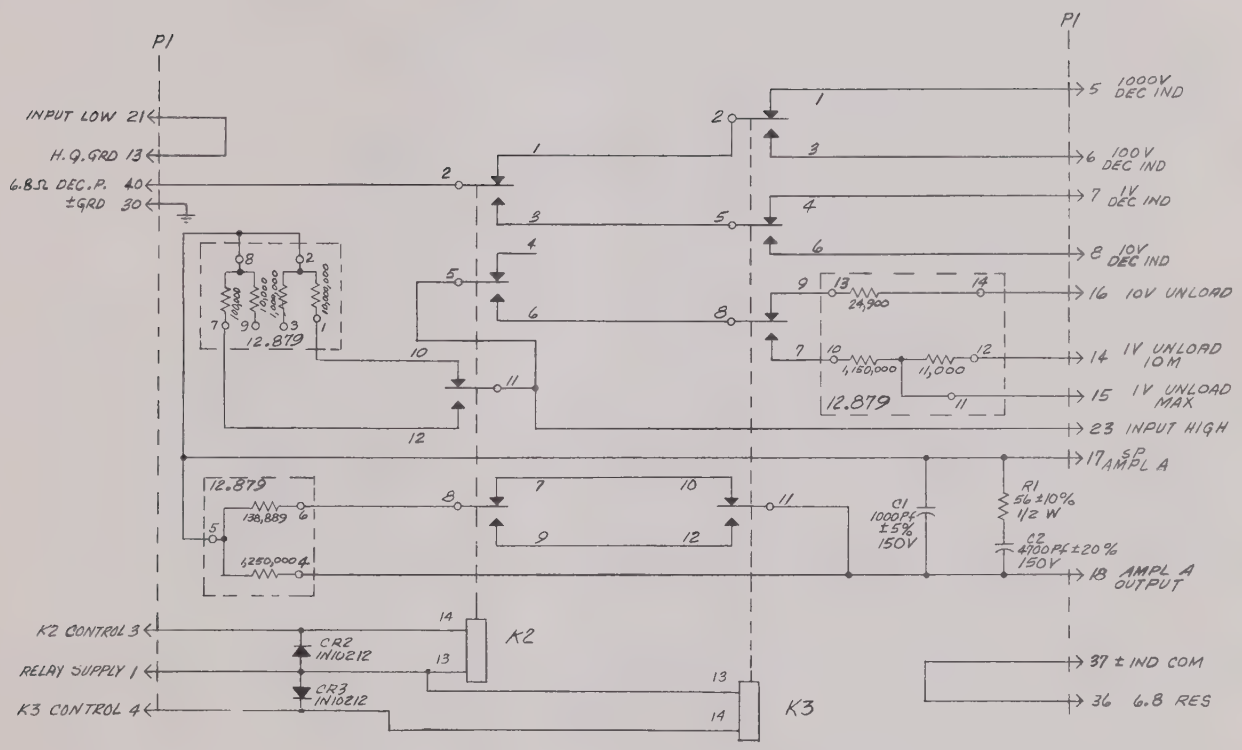
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN μF
RESISTANCE IS IN OHMS
TOLERANCE ON
FRACTIONS ± 1/64 | DECIMALS ± .005 | ANGLES ±
*TOL OF MATERIAL SUPPLIED

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SCHEMATIC MISCELLANEOUS NETWORK & 600Ω TD'M.
SHT. NO
SIZE
REV. NO
PROJECT 1723 C012 937 0S
SHEET OF SHEETS



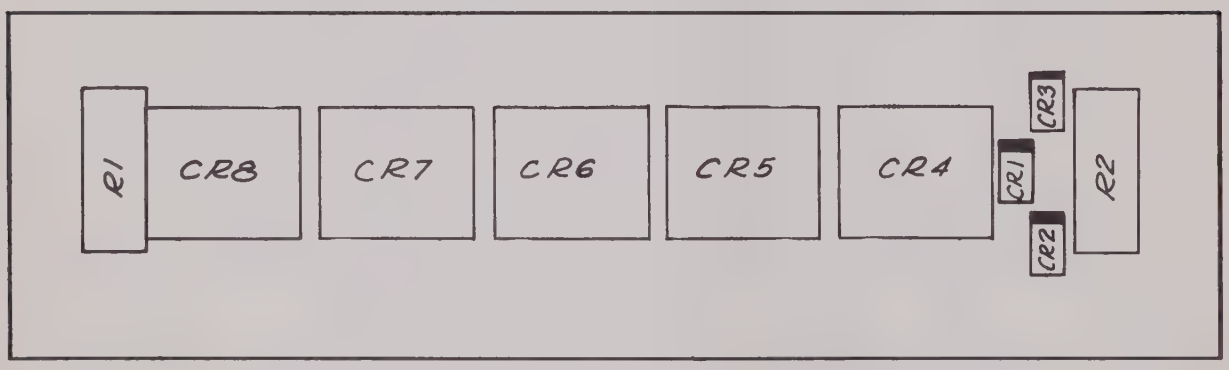


12.1036 Relay Network (6001 TDVM)

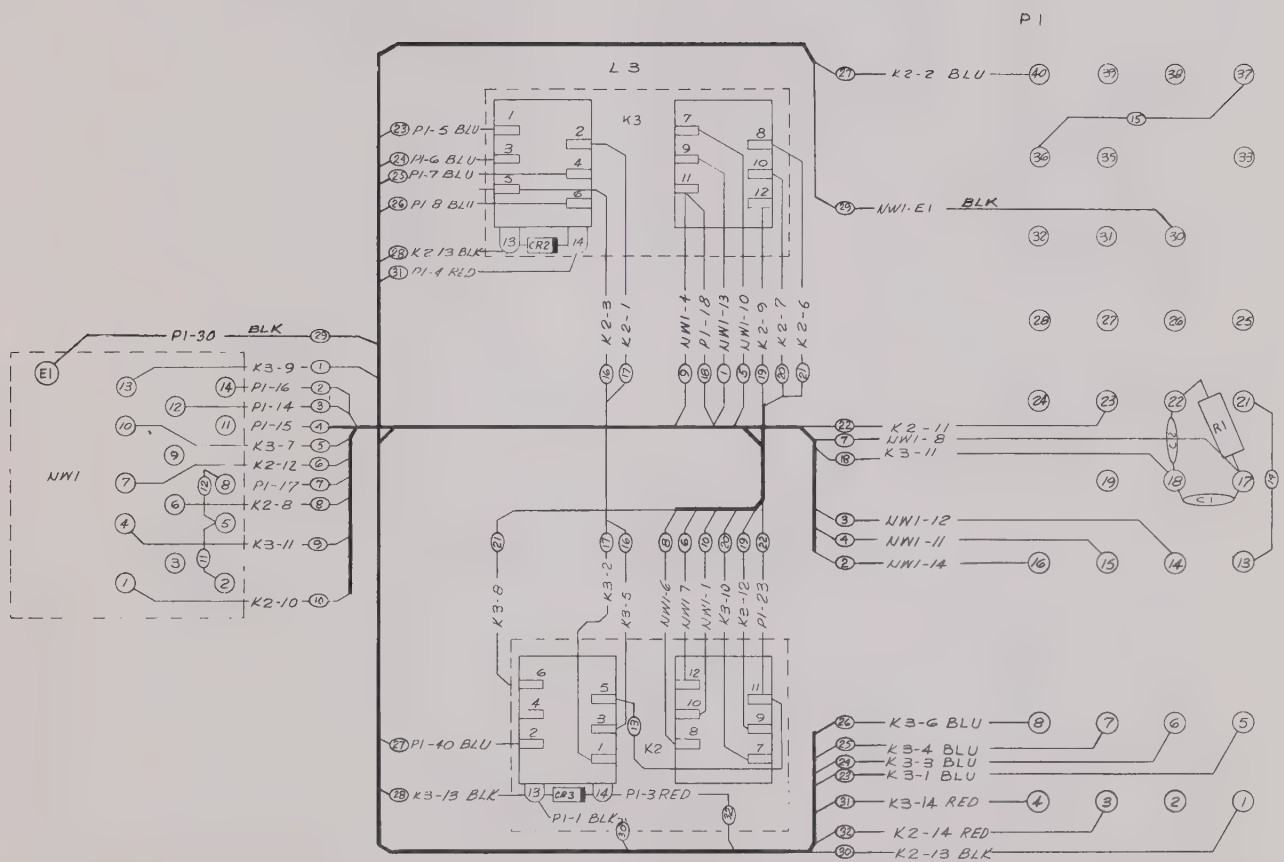


UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES		
CAPACITANCE IS IN pf		
RESISTANCE IS IN OHMS		
TOLERANCE ON		
FRACTIONS	DECIMALS	ANGLES
± 1/64	±.005	±
*TOL. OF MATERIAL SUPPLIED		

ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
SCHEMATIC RELAY NET 6001 TDYM	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	C012 1036 08
SHEET	



12.1106 Rectifier Network, P.S. (TDVM TR-48)



ELECTRONIC ASSOCIATES, INC.	LONG BRANCH, NEW JERSEY
WIRING	
RELAY NET.	
6001 TOWN	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	C 012 1036 0W
SHEET 1 OF 1 SHEETS	

UNIT NUMBER	SCHEMATIC NUMBER	PARTS LIST & NEXT ASSY.	DESCRIPTION	PARTS LIST USED ON:	PROJECT NUMBER
12.1106-1	012 1106 1S	012 1106 1P	SEE FIG. 2	A010 259 0P	19110
12.1106	B012 1106 0S	A012 1106 0P	SEE FIG. 1	A010 259 0P	19110

TABLE OF UNIT NUMBERS

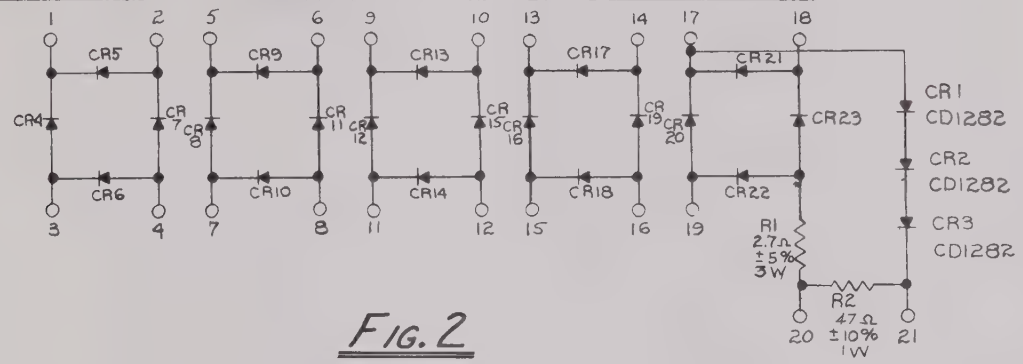


FIG. 2

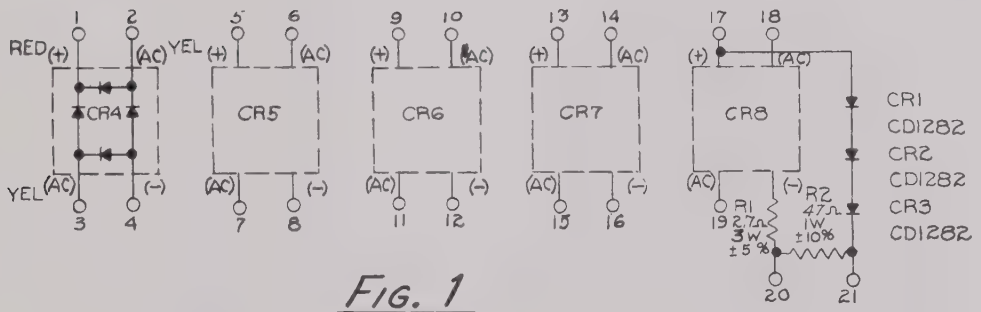


FIG. 1

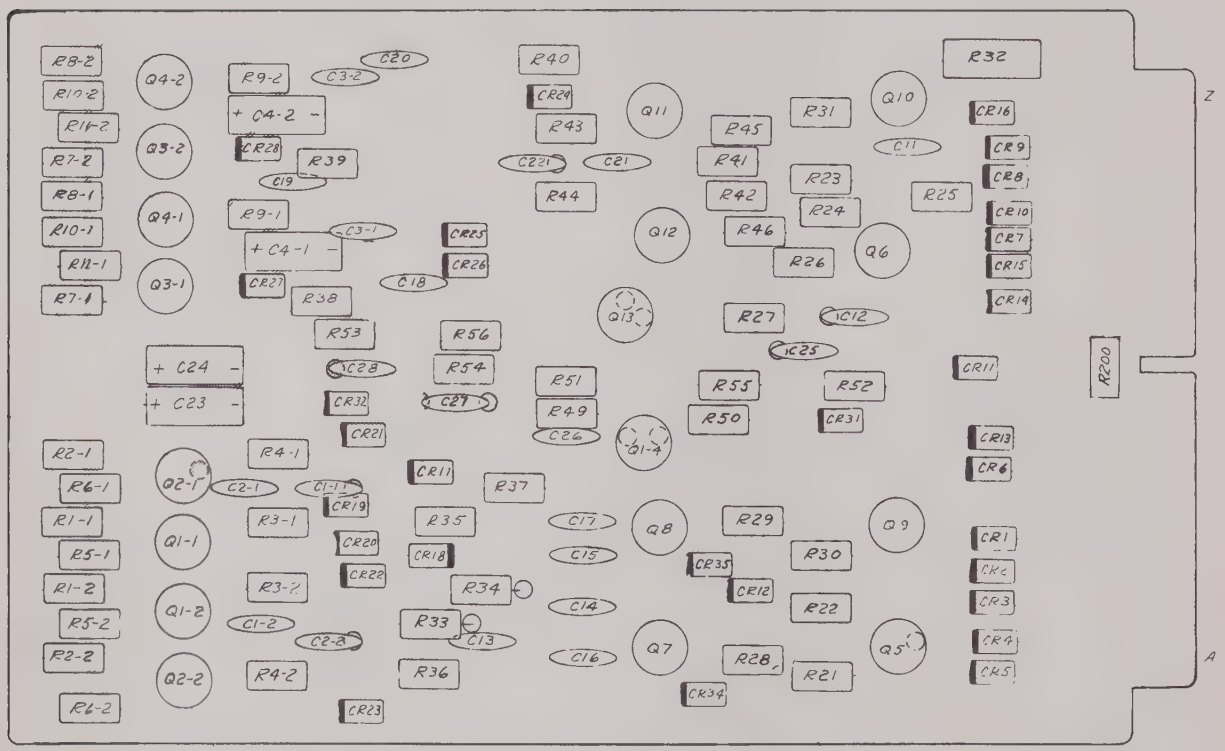
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN pf
RESISTANCE IS IN OHMS
TOLERANCE ON
FRACTIONS ± 1/64 | DECIMALS ± .005 | ANGLES ±
*TOL. OF MATERIAL SUPPLIED

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

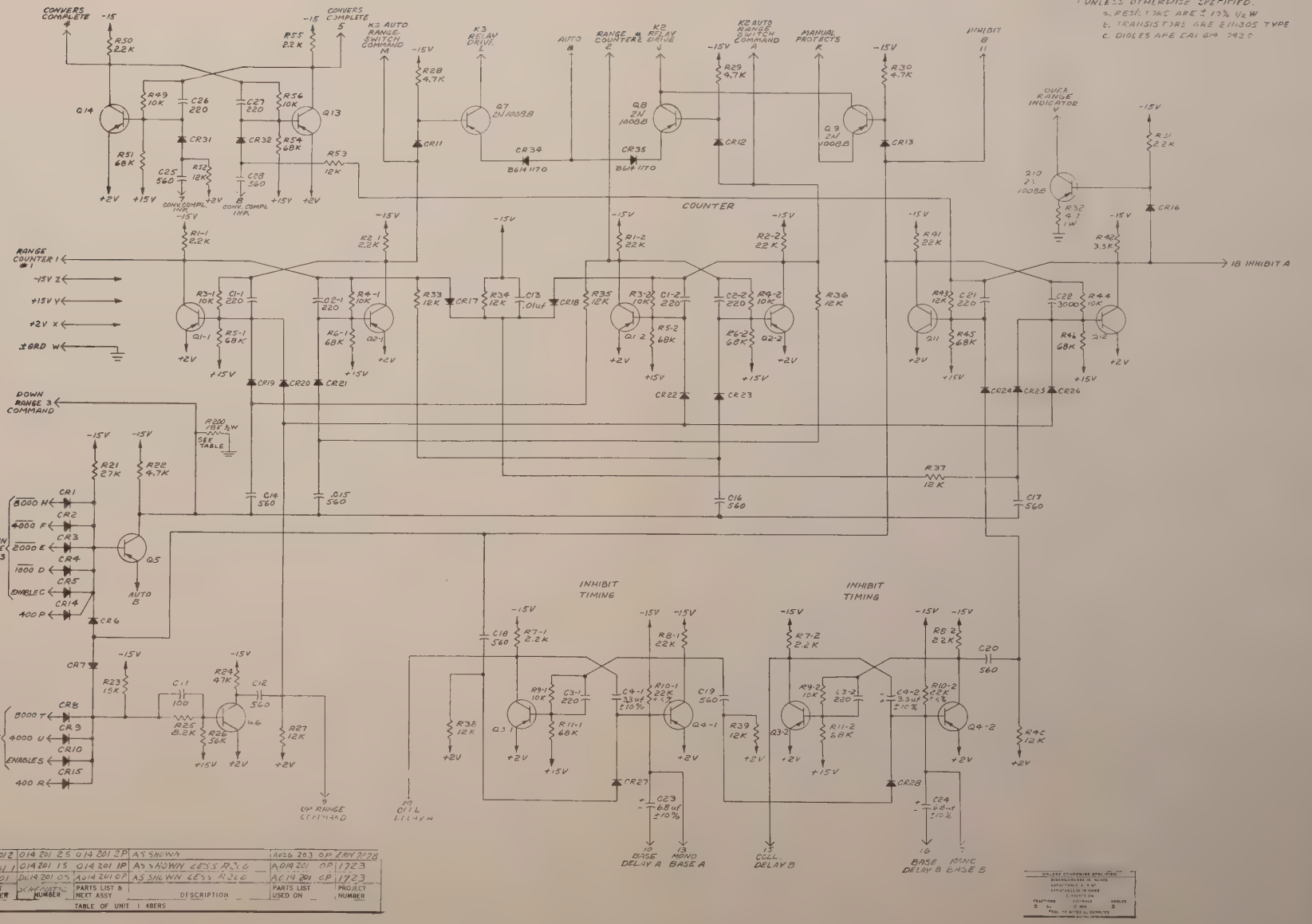
SCHEMATIC,
RECTIFIER NWK., P.S.
(TOVM TR-48)

SHT. NO.	
SIZE	
REV. NO.	
PROJECT 19110	B012 1106 0S

SHEET / OF / SHEETS



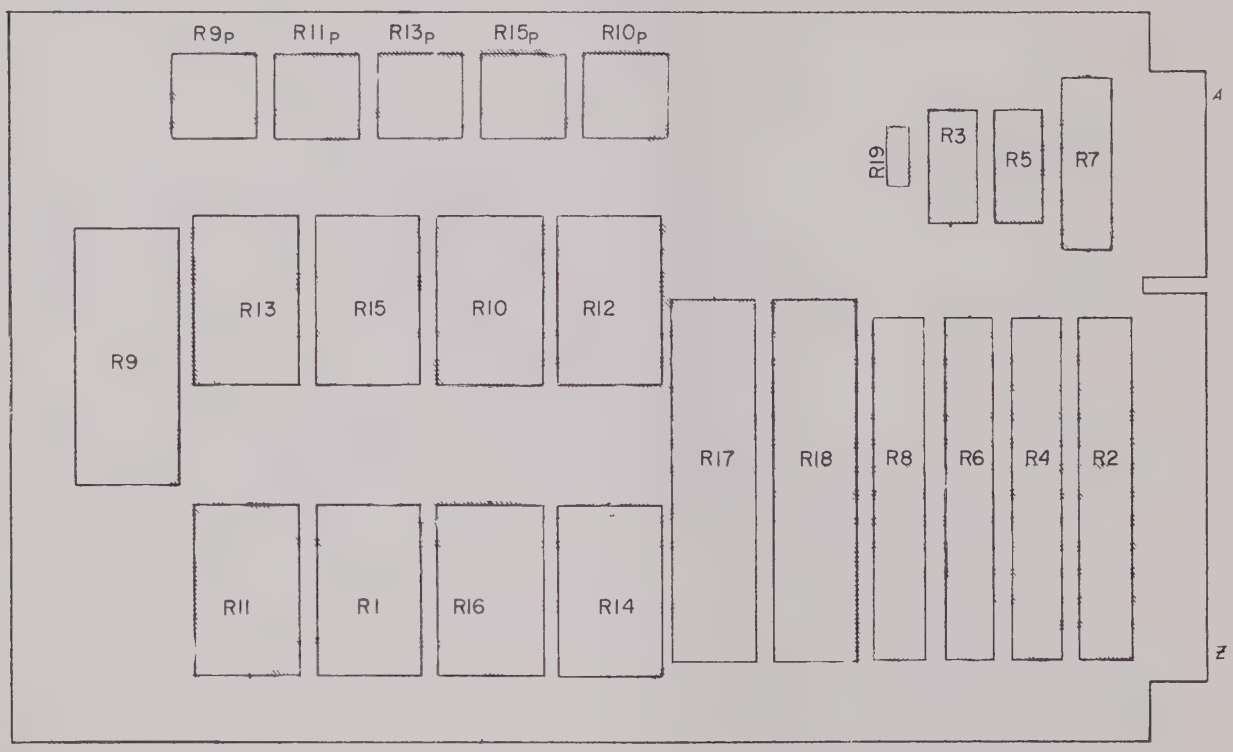
14.201 Auto Range SW. CKT. (6001 TDVM)



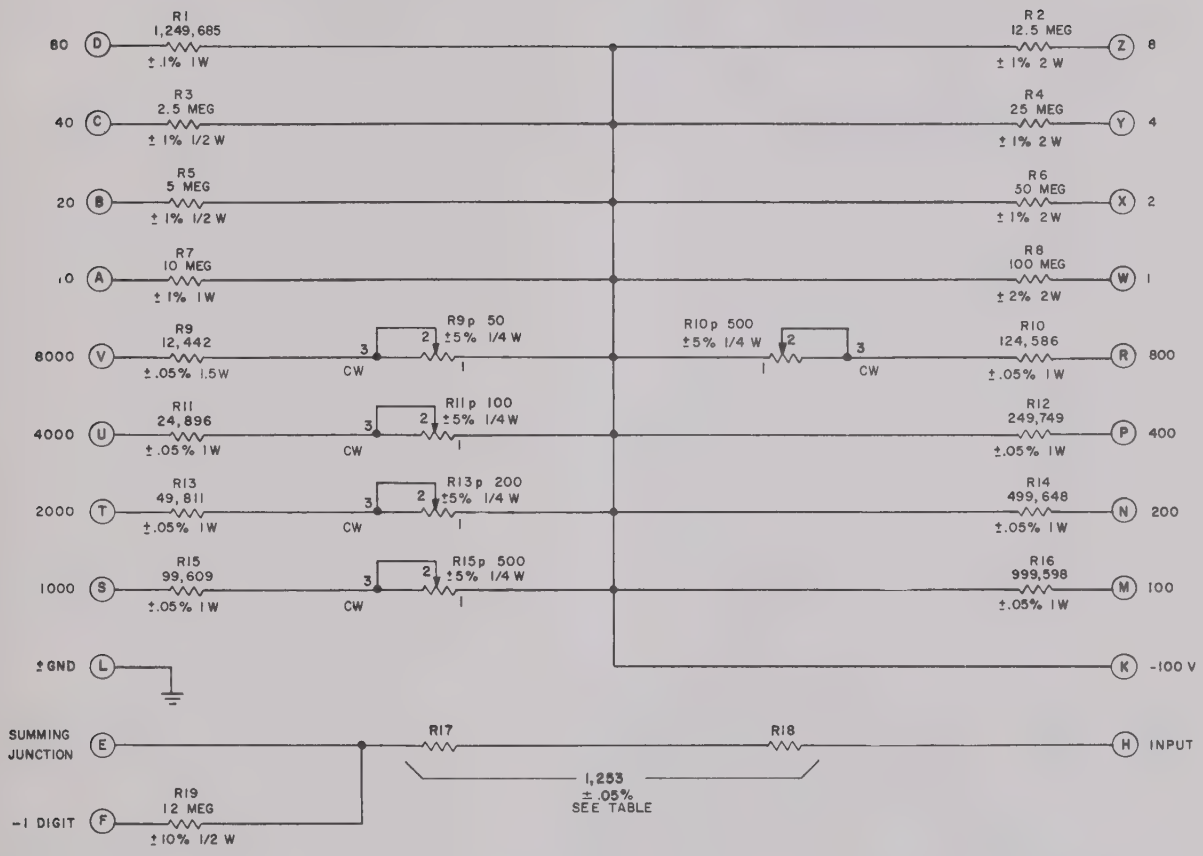
14.201 2	014 201 2S	014 201 2P	AS SHOWN	A026 203 OP	ERN 7778
14.201 1	014 201 1S	014 201 1P	AS SHOWN LESS R216	A014 201 OP	1723
14.201	014 201 0S	A014 201 OP	AS SHOWN LESS R216	A014 201 CP	1723
UNIT NUMBER	SCHEMATIC NUMBER	PARTS LIST & NEXT ASSY	DESCRIPTION	PARTS LIST USED ON	PROJECT NUMBER

TABLE OF UNIT 1 4BERS

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SCHEMATIC
AUTO. RANGE SW. CCT
SHT. NO.
SIZE
REV. NO.
PROJECT 1723
DOM 201 03



26.116 Summing Resistor Network



UNIT NUMBER	SCHEMATIC NUMBER	PARTS LIST & NEXT ASSY.	DESCRIPTION	PARTS LIST USED ON:	PROJECT NUMBER
26.116 2	026 116 23	026 116 2P	VALUE OF R17 & 18, 11 K ±.05%	A026 254 0P	ERN 6765
26.116 1	026 116 13	026 116 1P	AS SHOWN	A026 246 0P	ERN 6633
26.116 0	C026 116 0S	A026 116 0P	AS SHOWN		1877

TABLE OF UNIT NUMBERS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN MMFD
RESISTANCE IS IN OHMS
TOLERANCE ON
FRACTIONS ±1/64 DECIMALS ±.009 ANGLES ±
⊕ TOL. OF MATERIAL SUPPLIED

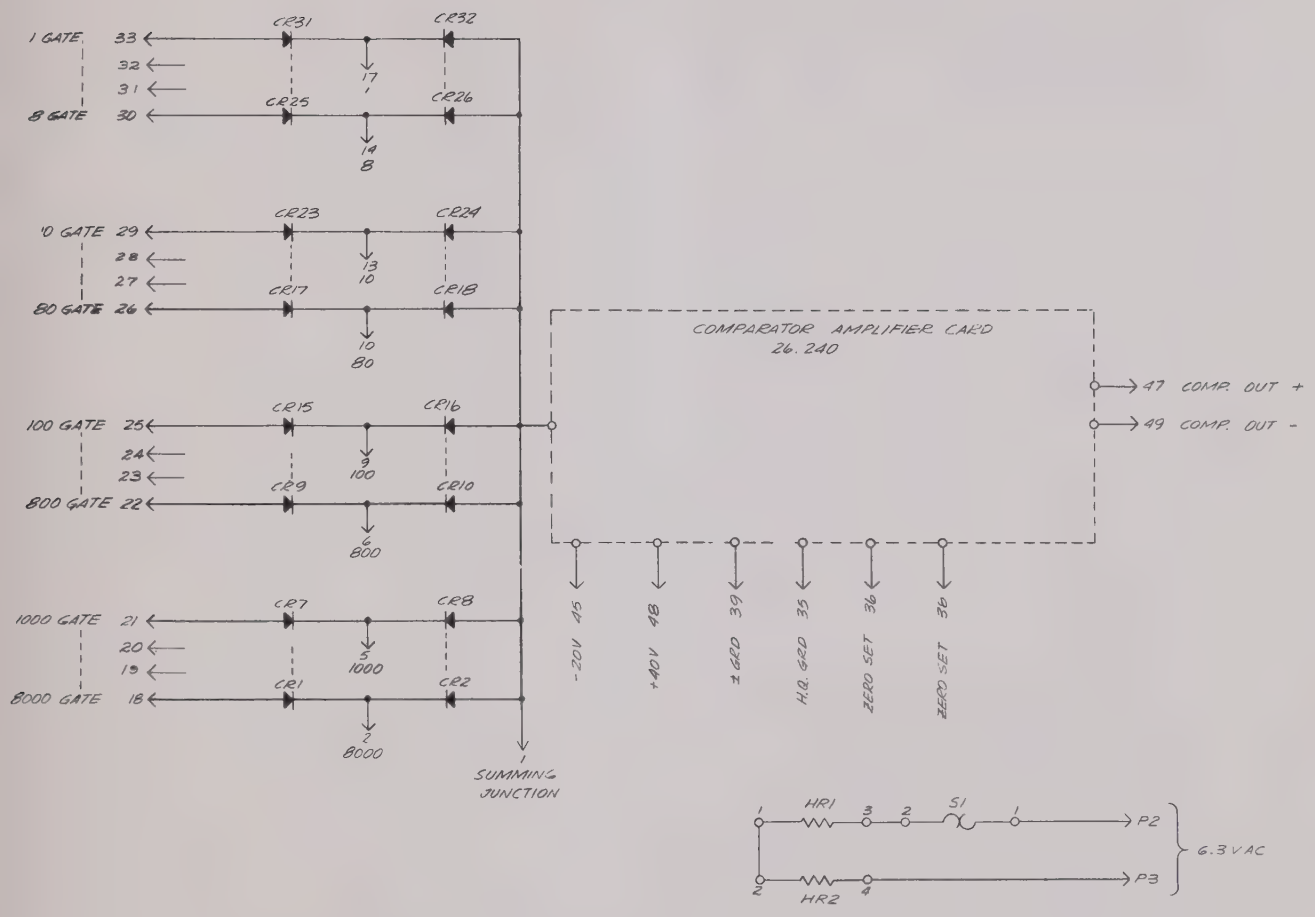
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

SCHEMATIC
SUMMING RESISTOR
NETWORK

SHT. NO.	
SIZE	
REV. NO.	
PROJECT	1877 C026 116 0S

SHEET | OF | SHEETS

NOTE:
1. UNLESS OTHERWISE SPECIFIED:
   a. DIODES ARE 614 242 0
   b. CONNECTOR PINS REF. TO P1.

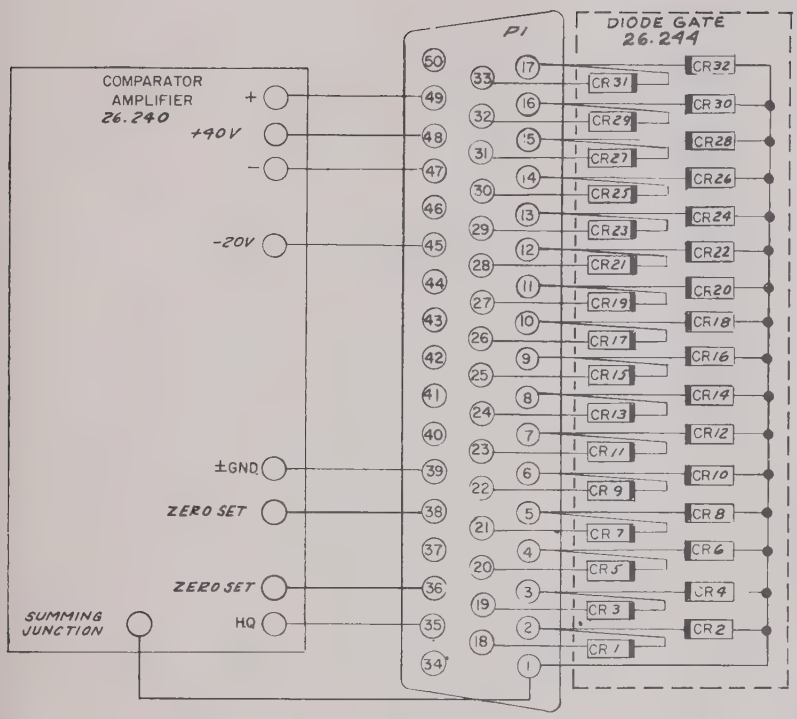


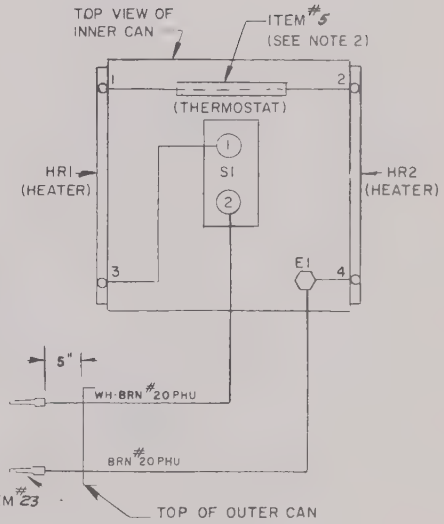
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
CAPACITANCE IS IN pf
RESISTANCE IS IN OHMS
TOLERANCE ON
FRACTIONS ± 1/64 — DECIMALS ± .005 — ANGLES ±
*TOL OF MATERIAL SUPPLIED

ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
SCHEMATIC COMPARATOR & DIODE GATE 6001 TO/M	
SHT NO.	
SIZE	
REV. NO.	
PROJECT 1723	C026 242 05
SHEET / OF / SHEETS	

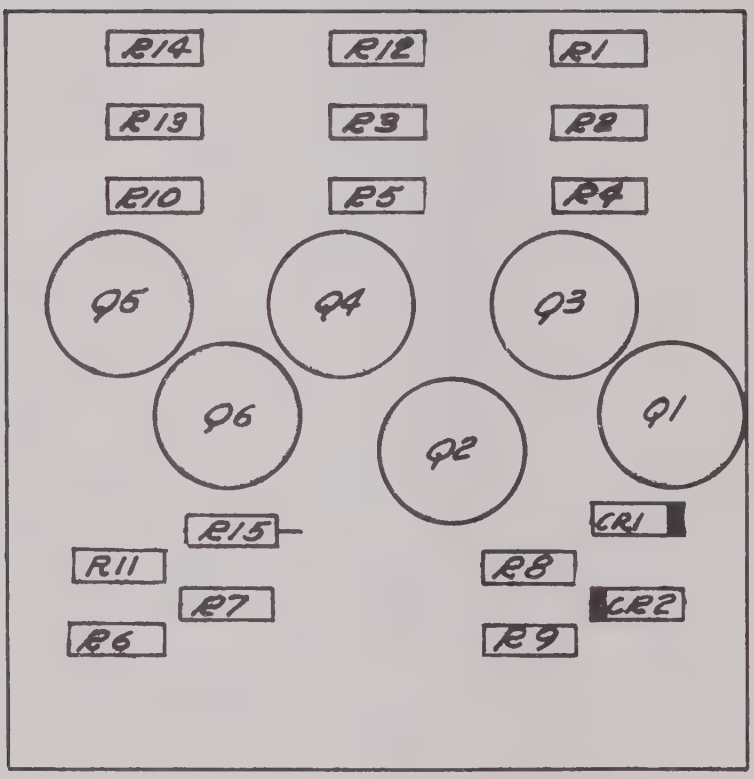
NOTE:

1. USE INSULATED TWO WAY CONNECTOR ITEM #5 TWIST WIRES TOGETHER & CRIMP WITH T&B TOOL WT—105M.
2. WIRES FROM POSITIONS 1,2,3,4 ON HR1 & HR2 ARE EXISTING WIRES ON HEATER.





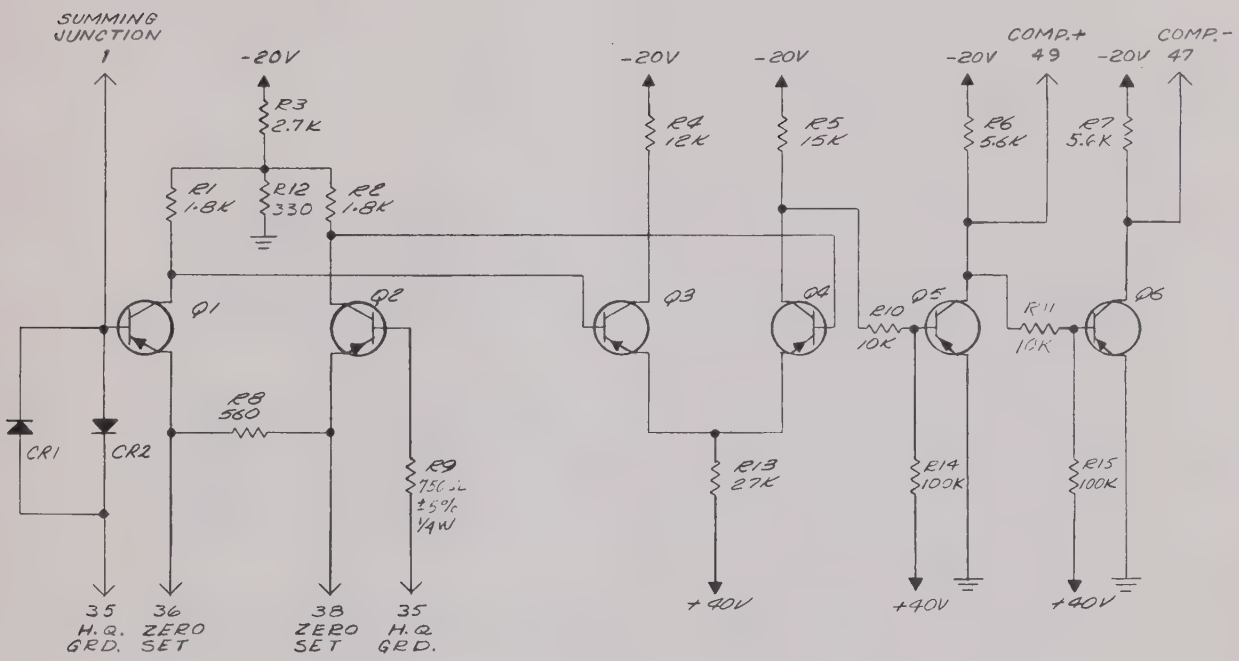
ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
WIRING COMPARATOR & DIODE GATE 6001 TDVM	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	B026 242 0W
SHEET 1 OF 1 SHEETS	



26.240 Comparator Amplifier

NOTE:
1. UNLESS OTHERWISE SPECIFIED:
   a. RESISTORS ARE ± 10% 1/2 W.
   b. TRANSISTORS ARE 2N1309 TYPE.
   c. DIODES ARE GA 023 O.

2



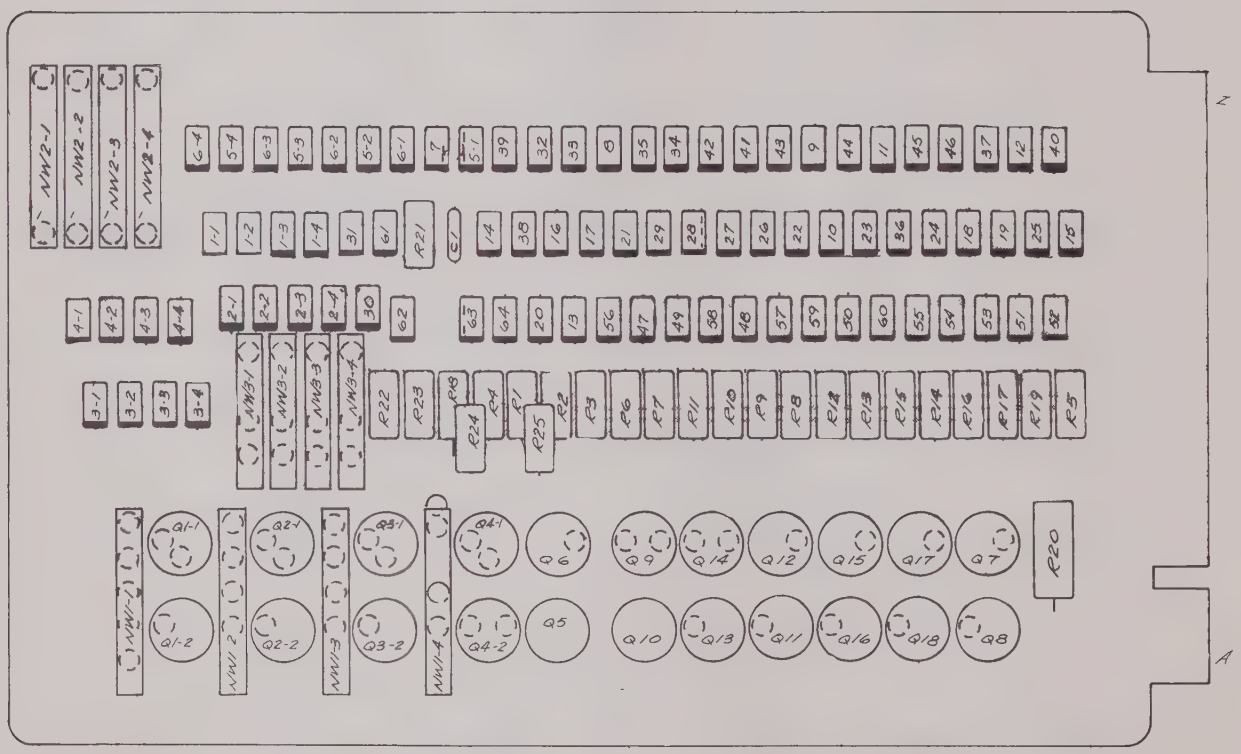
-20V 45 ⟵

+40V 48 ⟵

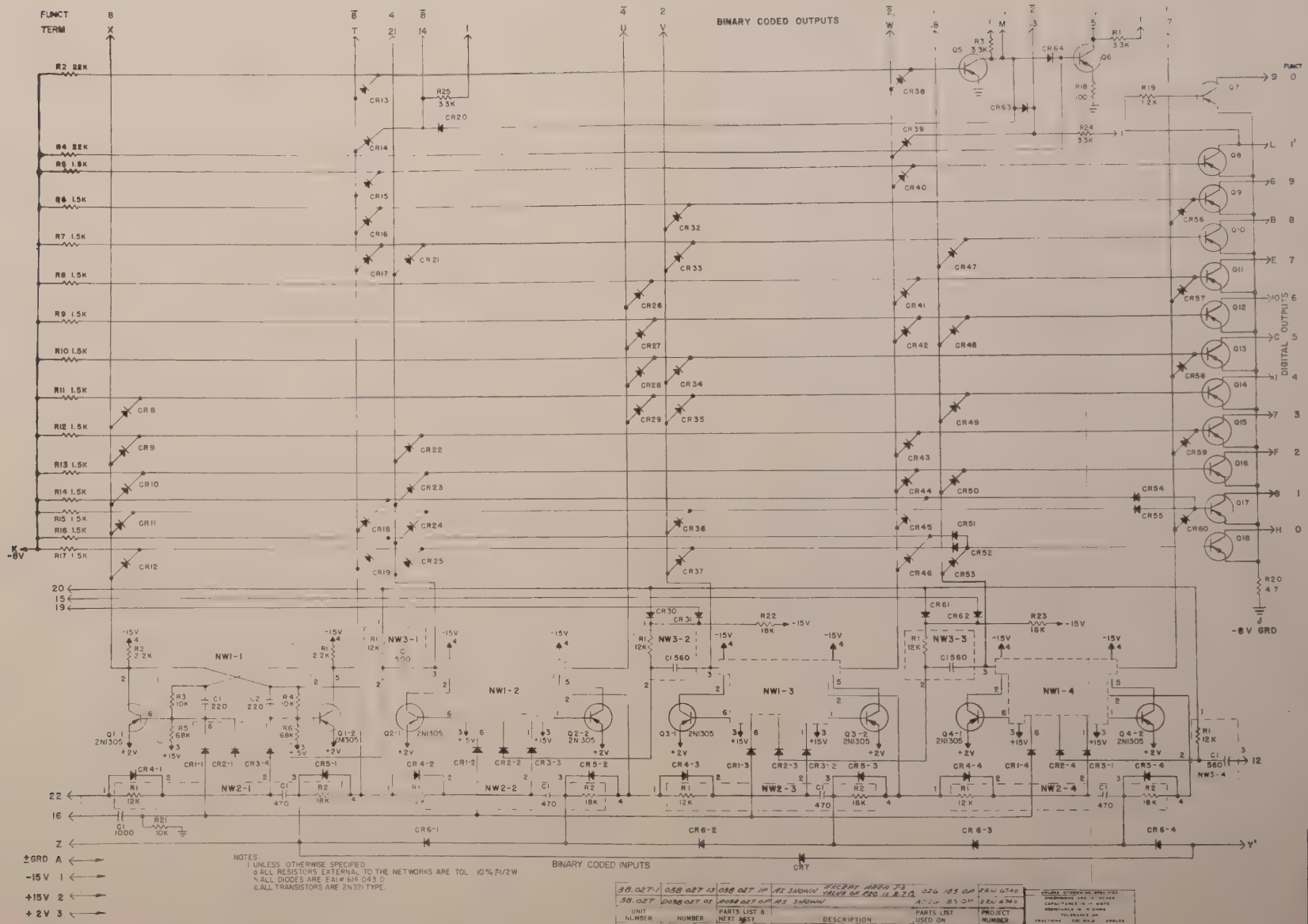
± GRD 39 ⟵

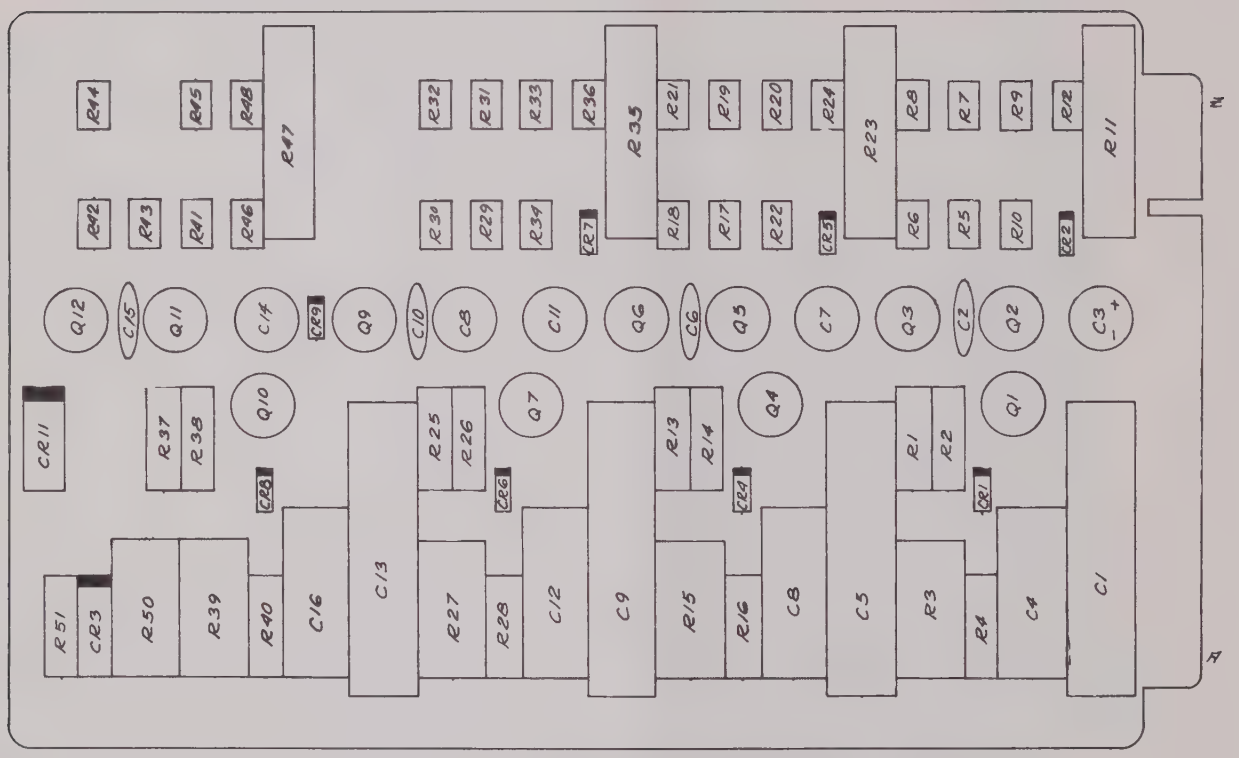
UNLESS OTHERWISE SPECIFIED		
DIMENSIONS ARE IN INCHES		
CAPACITANCE IS IN pf		
RESISTANCE IS IN OHMS		
TOLERANCE ON		
FRACTIONS	DECIMALS	ANGLES
± 1/64	± .005	±
*TOL. OF MATERIAL SUPPLIED		

ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
SCHEMATIC COMPARATOR AMPL.	
6001 TDVM	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	B 026 240 05
SHEET 1 OF 1 SHEETS	

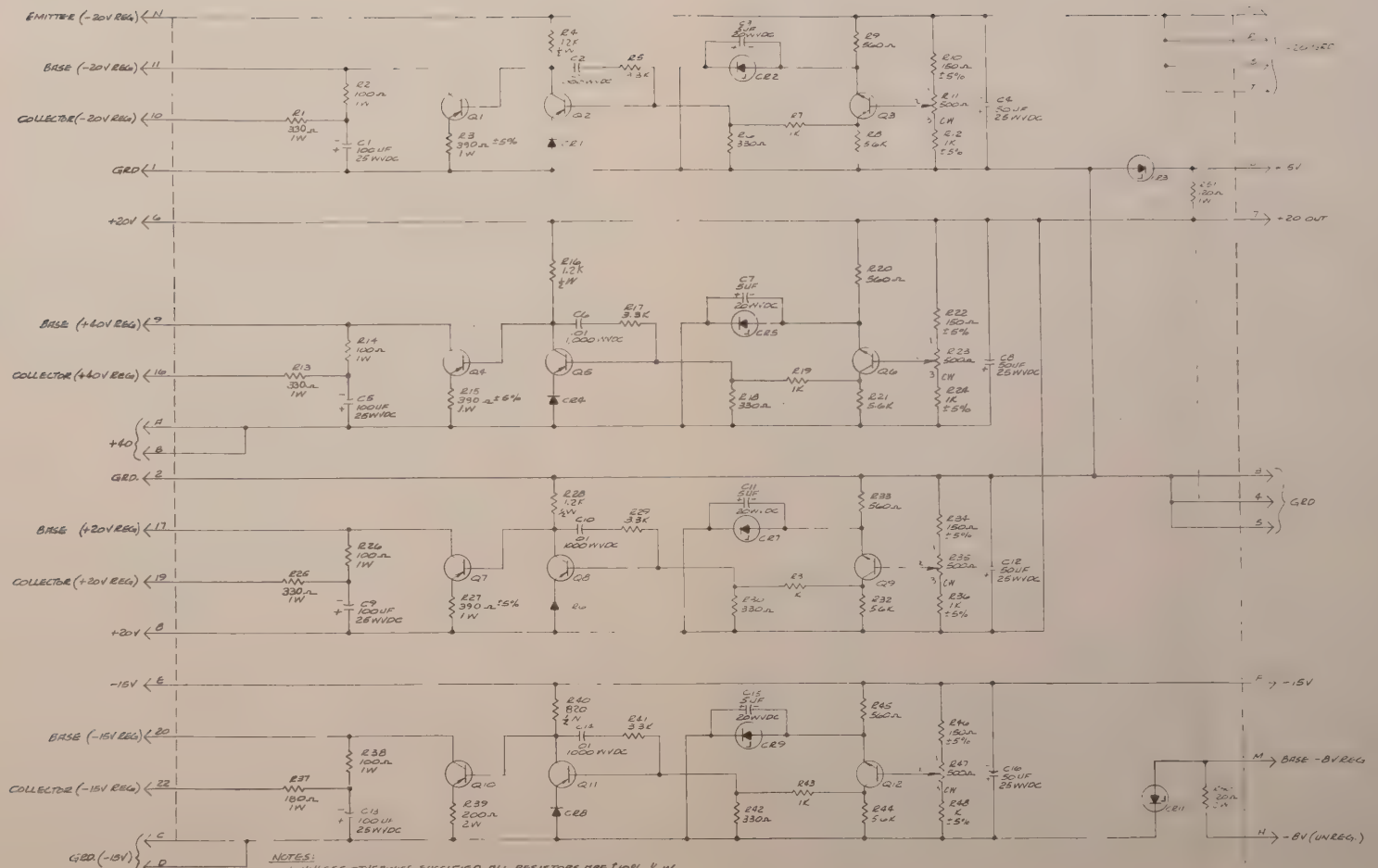


38.027 BCD Counter and Decimal Decoding Matrix (TDVM TR-48)


FUNCT TERM
BINARY CODED OUTPUTS
DIGITAL OUTPUTS
-8V GRD
BINARY CODED INPUTS
NW1-1
NW1-2
NW1-3
NW1-4
NW2-1
NW2-2
NW2-3
NW2-4
NW3-1
NW3-2
NW3-3
NW3-4
NOTES.
1 UNLESS OTHERWISE SPECIFIED
a ALL RESISTORS EXTERNAL TO THE NETWORKS ARE TOL 10% ±1/2W
b ALL DIODES ARE EAI# 614 043 0
c ALL TRANSISTORS ARE 2N321 TYPE.
ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY
SCHEMATIC
8 CO COUNTER &
DECIMAL DECODING MATRIX
(TDVM-TR48)
D038 027 05
TABLE OF UNIT NUMBERS



43.141 Regulator, P.S. (TDVM TR-48)



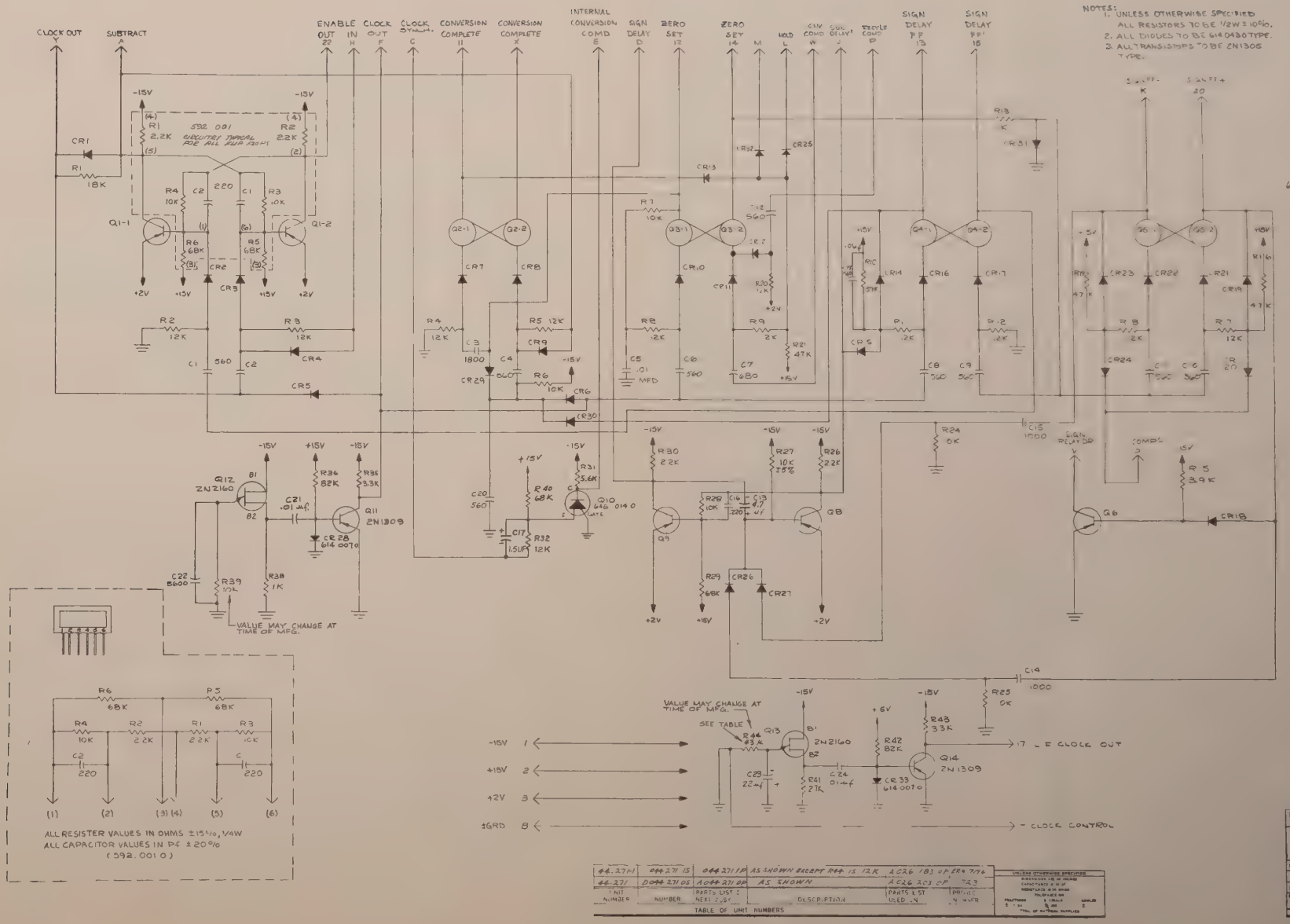
NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE ±10%, ½W.
2. TRANSISTORS Q 1, 4, 7 & 10 PART NOS. ARE 2N1039.
3. TRANSISTORS Q2, 5, 8, & 11 PART NOS. ARE 2N652.
4. TRANSISTORS Q3, 6, 9, & 12 PART NOS. ARE 2N377.
5. ZENER DIODE CR11 PART NO. IS 614 169 0.
6. DIODES CR1, 4, 6, & 8 PART NOS. ARE 614 043 0.
7. ZENER DIODES CR2, 5, & 7 PART NO. IS 1N718A.
8. ZENER DIODE CR9 PART NO. IS 614 131 0.
9. ZENER DIODE CR3 PART NO. IS 1N3024B.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
FRACTIONS ± 1/64 | DECIMALS ± .005 | ANGLES ±
FINISH PER MILITARY SPECIFICATIONS

ELECTRONIC ASSOCIATES INC.
LONG BRANCH, N.J.U.S.A.
SCHEMATIC
POWER SUPPLY REG. (10 W TYP)
SHT. NO.
SIZE
REV. NO.
PROJECT 1723
D 043 14105

44.271 Programmer (6001 TDVM)



44.271	044271 IS	044271 IP	AS SHOWN EXCEPT R44 IS 12K	A 026 183 OP ER# 776
44.271	D044 271 OS	A044 271 OP	AS SHOWN	A 026 203 CP 723
UNIT NUMBER	NUMBER	PARTS LIST NEXT ASSY	DESCRIPTION	PARTS LIST USED ON

TABLE OF UNIT NUMBERS

ELECTRONIC ASSOCIATES, INC.
LONG BRANCH, NEW JERSEY

SCHEMATIC PROGRAMMER

DRT. NO.	
SIZE	
REV. NO.	
PROJECT 1723	D044 2710S

APPENDIX III

SERVICING TECHNIQUES

1. INTRODUCTION

Although servicing and troubleshooting procedures applicable to transistor circuits are similiar in many ways to the techniques used with vacuum tube circuits, certain differences exist, and several extra precautions are necessary when servicing transistor circuits. The following suggestions and techniques are given to aid maintenance personnel who are not familiar with servicing transistorized equipment.

2. ETCHED-CIRCUIT BOARD SOLDERING

The techniques and precautions employed while soldering any electronic equipment still apply, but there are several additional factors to be considered when working with etched-circuit boards.

a. Wire leads or components fastened to the board by their leads may be replaced using the following procedures:

(1) Grip the lead to be removed with a pair of long-nose pliers, (in cases where this is impossible due to extremely short or hidden leads, the component itself must be carefully grasped). While applying pressure to the lead, touch a well-tinned, small (40 watt or less), soldering iron to the fillet. If the lead does not slip out immediately, remove the soldering iron and recheck to be sure the correct fillet is being heated.

(2) Clear the excess solder from the hole by touching the iron to it briefly and either blowing the excess solder out or carefully pushing it out with a soldering aid (GC Electronics No. 9093 or equivalent).

(3) Bend the leads on the new component or jumper to fit the board connections. Insert the component, but *do not* cut the leads.

(4) With the component or jumper held in place, touch the soldering iron to the lead and allow solder to run down the lead and form a fillet. Heat should be applied to the lead only until the fillet has formed. It is not necessary to fill the hole with solder, and some components such as transistors and diodes may be damaged by prolonged application of the soldering iron.

(5) After both leads have been soldered, use a pair of diagonal cutters to cut the lead off as close to the board as possible. Use the soldering aid to carefully scrape any excess flux or solder off the board.

b. Replacing components such as transistors, relay and chopper sockets, potentiometers, or networks with multiple connections is accomplished in essentially the same manner. Removal of these components is much easier if special tips such as the Ungar Electric Tools No. 856 (5/8" dia. cup) and No. 858 (bar) are used. These tips are used for component *removal* only, and permit all leads to be freed simultaneously.

If the above procedures are strictly adhered to, no trouble with the etched conductor itself should be encountered. If, however, a conductor becomes cracked or broken it may be repaired by carefully soldering a tinned piece of bus wire over it. Again extreme care should be taken not to overheat the strip and cause it to separate from the board.

3. TRANSISTOR SERVICING

Most transistors are mechanically rugged, but they are easily damaged by excessive heat. If it becomes necessary to solder near a socket-mounted transistor, the transistor should be removed to prevent damaging it. When the transistor is soldered to the board, extreme care should be taken to prevent damage to it from overheating. Always use a small, well-tinned soldering iron and work as quickly as possible.

Transistors and small diodes which are soldered directly to the board should be removed only when there is strong reason to believe they are defective; they are often over-heated while being removed. When soldering transistors or diodes a heat sink should be used, whenever practicable, on each lead as it is soldered. Two common methods of protecting these semiconductors from overheating while soldering are holding the lead with a pair of long-nose pliers, or clipping an alligator clip, the jaws of which have been filled with solder, on the lead.

Power transistors, which are usually used in power amplifiers and power supplies, are mounted on metal chassis plates which function as heat sinks to dissipate the heat generated during normal operation. The metal case of a power transistor is usually the collector and operates at relatively high potentials. For this reason power transistors must be mounted so that they are electrically insulated from the heat sink. At the same time, heat from the transistor must be transferred easily to the heat sink. A common method of accomplishing this is by using a mica, anodized aluminum, or fiberglass washer coated with silicone grease. The washer provides electrical insulation, and the silicone grease increases the heat conduction. When replacing a power transistor, use only a single washer, and coat both sides with silicone grease (Dow Corning

No. 4 Compond or equivalent). As a final precaution before applying power to the unit, check the resistance between the body of the transistor and the heat sink to ensure that no short or high resistance leakage path exists between these points.

Diodes, electrolytic capacitors, and the transistors themselves used in transistor circuits are easily damaged by voltage overload. For this reason transistors should never be removed or inserted with power applied, and special care must be taken in the selection and use of test equipment. Signal generators commonly used in servicing vacuum tube circuits are often capable of producing enough output to overload and permanently damage the diodes, electrolytic capacitors, and transistors used in transistor circuits. Always start with the minumum output signal and slowly increase it to the desired level.

The meter used for continuity and resistance checks must be carefully chosen. Some ohmmeters use batteries with a higher voltage rating than the transistors and capacitors being checked, and will destroy them. For this reason a meter with a 1-1/2 volt battery (Triplett Model 630A or equivalent) is recommended. In order to prevent damage to the small electrolytic capacitors used in these circuits it is essential to determine the polarity of the ohmmeter leads. This may be done easily by using another meter set to a low dc scale.

4. TRANSISTOR TROUBLESHOOTING

As with any other type of electronic circuit, the first step in troubleshooting transisor circuits is a visual inspection for charred, discolored, or leaky components; broken, shorted, or loose connections; heavily tarnished or broken connectors; and physical damage to the board itself. The next step is to replace any relays, ovens, or choppers, which are socket mounted on the board, with units known to be good. This is done not only because it is fairly easy, but also because each contains mechanical moving parts which may fail due to normal wear. If the trouble is not located by either of these steps, the board may be dynamically tested by applying all supply voltages and a signal input and then checking voltages and signals on the board until the trouble is isolated. If dynamic testing is impossible due to the lack of suitable test equipment, or availability of "down time" on the equipment in which it is used, the trouble can usually be located through resistance and continuity checks.

Refer to the schematic when making resistance checks to be sure that meter polarity is correct for any electrolytic capacitors in the circuit and that parallel dc paths are not affecting the readings. When the board is removed many components are naturally isolated by the plug or pin connections. Others are effectively isolated by capacitors in series with them. When it becomes necessary to unsolder and lift one end of a component from the board to isolate it for resistance checks, resistors should be chosen whenever possible as they are the component

least likely to be damaged by the heat. In many cases, by carefully selecting the correct lead to disconnect, several components may be isolated at one time. It is not usually necessary to risk overheating a transistor by unsoldering it to make resistance checks. For example, lifting one end of the collector load resistor and one end of the emitter resistor would effectively isolate the transistor in a normal transistor amplifier stage.

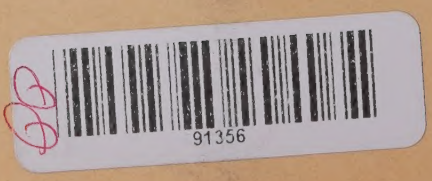
Once a transistor is isolated, it may be checked using the following procedures:

a. Set the ohmmeter to a high range and connect it between the base and the collector leads; reverse the leads and note which connection caused the higher reading. This is the reverse-bias direction.

b. Connect the ohmmeter to reverse-bias the transistor and note the reading. Short the base to the emitter. The reading should decrease. Remove the short.

c. Move the lead on the base to the emitter and note the reading. Re-connect the short. The reading should increase.

This test will indicate a burnt-out transistor but not a weak or high-leakage transistor. If the transistor is still suspected, and no other troubles are found, substitute one known to be good.


91356